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THE ARROWHEAD

CALIFORNIA

A

GEOLOGIC WONDERLAND

BY

GILBERT ELLIS BAILEY, A.M., PH.D.

Professor of Geology, University of Southern California; formerly geologist of Wyoming; field geologist, California State Mining Bureau; author of "Salines of California," "Origin of Hot Springs," "Arrowhead Hot Springs," etc.

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FOREWORD

Most of these sketches were published in the *Los Angeles Times,* and are reproduced by permission.

Our magnificent system of highways has made accessible all of the places described, and this little book is for the purpose of explaining some of the interesting points in their origin.

Purely technical terms have been avoided, the object being to add to the enjoyment of the traveler by helping him to understand as well as to enjoy the marvels of nature in the world's greatest playground: California, the geologic wonderland.

THE AUTHOR.

TO
REBA BOSTON BAILEY
MY WIFE

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A GEOLOGIC WONDERLAND

California is a geologic wonderland on an exceptional scale. These wonders lie along magnificent boulevards and are easy to reach and study at leisure and in comfort.

Geology is simply the story of the earth as told by the valleys, mountains, rocks and minerals from "in the beginning" to the present time. The prehistoric story of man himself is recorded in the kitchen-middens around San Francisco Bay, in the marl pits of Lomita, among the saber-toothed tigers of Rancho la Brea and in the Indian graves of our islands.

* * *

No other state presents greater diversity from the highest peaks in the United States to valleys below sea level; from an active volcano to living glaciers; from broad, fertile valleys to arid deserts. Our vast Sierras contain the beauty of Lake Tahoe, the grandeur of the Yosemite and the majesty of the prehistoric Sequoias. They are the highest peaks in the United States and form a gigantic wall of skyline guardians along the eastern border. Mt. Whitney, 14,502, is the highest peak in the Union; but there are fifteen others that rise over 14,000 feet; thirty over 13,000; forty over 12,000; forty-eight over 11,000; seventy-five over 10,000 and 120 over 9000.

There are seven living, moving glaciers on these mighty crests that are sluggishly crawling rivers of ice, with huge moraines; while the glacial lakes are

too numerous to count as they gleam like emerald mirrors among the rocks.

Along the western flanks of the Sierras stretches the famous "Mother Lode" for 178 miles, known throughout the world for its treasures of gold, silver and other metals and for its romantic history.

* * *

The coast ranges carry rich deposits of petroleum, asphalt, quicksilver, magnesite, diatomaceous earth and chromite.

The desert ranges, with feet half buried in the sand, have on their flanks deposits rich in iron, silver, lead, tungsten, zinc, vanadium and marble; while their sinks or "dry lakes" are treasure houses of borax, salt, gypsum, strontium, potash and sodas.

The volcano of Lassen Peak is the only one in activity in the United States. Its flanks reek and bubble with hot springs, little geysers, mud springs, solfataras and new cinder cones. We have also the extinct—maybe only sleeping—volcanoes of Mt. Shasta and the Marysville Buttes; while the desert is dotted with craters, cones and lava flows.

The Devil's Post Pile, 400 feet high, is a far finer example of columnar basalt than the Giant's Causeway or Fingal's Cave and is situated in Mono County in the midst of a beautiful mountain meadow.

* * *

Canyons like the mighty Yosemite, Hetch-Hetchy and Kings River are unrivaled in majesty, beauty and geologic interest. This State offers exceptional opportunities to study "U"-shaped canyons finished by the glaciers and "V"-shaped canyons cut by the streams.

The valleys of the East are mostly made by their filling or erosion; but we have those and also great valleys that are sunken blocks, synclinal and even "hanging" valleys.

Death Valley, Inyo County, of tragic history, is 175 miles long by eight to twenty-five miles wide. It lies silent and mysterious far below sea level; with its floor covered with salt, borax, sodas and other raw materials.

Salton Sea of Riverside and Imperial Counties is 275 feet below sea level and shows the old beaches of the ancient "Blake's Sea"; while coral reefs are on the mountain tops near by; and in the great surrounding valley are thriving cities, cotton fields and casaba ranches galore; all below sea level.

* * *

The great Mojave Desert is the climate regulator of the entire West, where the hot air rising from the sun-heated sands draws in the cool, moisture-laden air from the ocean, giving California a climate finer than the famous Riviera of the Mediterranean or Nice or Genoa. One may stand in the streets of Los Angeles in winter time surrounded by delicate flowers in bloom and take an electric car and in one hour be snowballing on top of the Sierra Madre.

The "Great Valley," or central valley of the state, is an empire of itself, 500 miles long and from twenty to fifty wide, it covers 20,000 square miles; a larger area than Vermont and New Hampshire together. It is larger than Denmark, Holland or Bosnia. It is a vast, highly cultivated, fertile plain without a rock outcrop, rich in alluvial fans, phenomena of erosion and of the work of water.

The coast, 1200 miles long, is marked by wave-cut terraces that prove that California is a young and rising country from a geological standpoint. Its headlands, drowned harbors, submerged channels, islands, river deltas, salt marshes and its beach placers of platinum, thorium and gold all make it of great interest from both the scientific and commercial standpoints.

* * *

The geologic history of the whole earth is completely shown in this state from "in the beginning" to the most recent formations; something that cannot be said of any other equal area. There are bold sections of the rocks of each period from the pre-Cambrian to the present. The Tertiary formations are shown on a scale unequaled elsewhere. The records of the Quaternary with the Rancho la Brea fossils are the wonder and admiration of the scientific world; while the Mercer, Hawver, Samwel's and Potter caves are all rich in ancient mammal remains.

* * *

Over 20,000 feet of the Cretaceous rocks are exposed, while the Jurassic measures over 15,000 feet in thickness. The formations of the Triassic are the standard of that period for the rest of the world. The rocks from the Cambrian to the Carboniferous are wonderfully exposed in the desert ranges. The Cambrian, with all three of its divisions shown, is attracting world attention; and the "oldest muds in the world" in Inyo County have already become a mecca for scientists. The fossils, the medals of creation that mark the stony pages of the world's history, are

so abundant that they are hauled away by the carload to fill the museums of the East.

* * *

California yields a greater number and variety of commercial mineral products than any other state in the Union, and more than any other equal area on the face of the globe. The total output for 1921—the latest available statistics—was $268,157,426, an increase of $26,000,000 over the preceding year, and a total that was surpassed only by the four leading coal states in the East.

Fifty-one different mineral substances are mined and over twenty-five more exist and await development. This does not include the gems and jewelers' material that number over 100, some of which are found nowhere else.

* * *

The greater portion of the minerals and ores produced in the state are found exclusively in the seven southern counties and within a radius of 200 miles from Los Angeles. This city is the distributing point and it is within a few hours' ride by auto from the richest mining districts.

The yield in petroleum was $203,138,225 and all of this came from the southern counties, except $4966 from San Mateo County. The production of natural gas was $4,704,678 and of this only $49,697 came from the northern counties; while the 53,000,000 gallons of gasoline made from the gas was all from the south.

* * *

We lead all of the states in the production of gold, silver and platinum, and alternate in the front of the

procession, with Colorado in tungsten, and in petroleum with Oklahoma.

California has been for years the sole producer of borax and for many years the sole source of domestic supply of magnesite and chromite. This state supplies 75 per cent of the national output of mercury.

Nearly all of the bituminous rock, asphalt, chromite, magnesite, infusorial earth, lithia, molybdenum, platinum, strontium, zinc, tungsten, lead, bismuth, thorium, tantalum, borax, potash and sodas are mined in the southern counties; and most of this list of minerals would be considered rare in any locality.

* * *

There are 13,000 men at the mines, dredges, quarries, cement plants; 25,000 men in the oil fields, exclusive of the refineries, who are adding new wealth to the world at the rate of $7000 for each man employed.

There are over thirty-five factories in Los Angeles alone that are making over seventy different products from this raw material; yet everything is in its infancy. Germany was made rich by her chemical industries; but she had only a fraction of the raw material that is mined near Los Angeles.

No wonder that this city is the white spot on the maps of the world! No wonder that these resources are a magnet that draws factories to this commercial center! No wonder that this city is growing by leaps and bounds, for it is the distributing center of the world's geological wonderland.

THE ARROWHEAD

There is a mysterious, gigantic arrowhead on the face of a mountain in the San Bernardino range that has excited the admiration and wonder of the primitive savages long before the Spaniards came; and it arouses the same emotions today in everyone who sees it. It is a universal symbol as quickly recognized by the savage from the uttermost parts of the earth, as by the expert scientist. It is a symbol that does not require any stretch of the imagination to recognize, for it is without flaw from barb to barb, and from shank to point. It is clearly and sharply defined as it leans, flat and gray, against the clear green and brown mountain, pointing directly downward towards the wonderful, healing hot springs.

It is in keeping with its setting, not small, or dim, or obscure, but standing out in clear and sharp relief, majestic and gigantic. It covers seven and one-half acres, having a length of 1375 feet, and a width of 449 feet, making it visible to the naked eye for thirty miles.

It is not artificial and was not made by the hand of man, primitive or modern; but it was flung against the steep mountain side by the hand of nature herself. It is the work of an ancient cloudburst. At the top of the shank lies a horizontal ledge of hard rock. Below lie two ridges forming a huge "V" with the tops nearly 500 feet apart, and meeting at the foot of the Arrowhead.

Long ages ago the waters of a cloudburst fell over the reef of hard rock in such volume as to cut through

the thin soil which formed a temporary dam, spreading out the waters east and west to the confining ridges. Then as the flood accumulated, it washed soil, brush and everything else off, clean down to bedrock.

The flood being confined by the V-ridges, the clean bedrock formed a perfect replica of an arrowhead. At the bottom of the V the flood turned sharply to the west, cutting a little concealed ravine into the Hot Spring Canyon.

Before the flood the ridges were covered by a heavy growth of dark brown chemise; but afterwards there was not soil enough left for that bush to grow; but a light and scanty growth of white sage sprang up and covered the Arrowhead. Today the great symbol is sharply framed by the dark brown chemise, around the white sage of the Arrowhead.

The same phenomena may be observed in many other places in the range where the heavy growth of chemise and other brush has been destroyed and where white sage has taken its place; but nowhere else has it happened to take the form of such a perfect pattern and design.

Such a well-known symbol was naturally regarded by the superstitious savages as the work of the Great Spirit, and therefore sacred. The boiling hot springs towards which it points must have convinced them that it was placed on the mountain side as a guide. As everything touched by the Great Spirit is sacred, it is easy to understand why these hot springs have been a sanctuary, or neutral ground for ages. Members of any tribe could gather there and no war would be made upon any of those that sought to drink the healing waters or treat their wounds with the hot

muds. This also explains why these springs were known to tribes hundreds of miles away, and why they have led explorers, hunters and colonists to this part of California and to the Mormon settlement at San Bernardino.

This arrowhead has been known in history for over 150 years, and in Indian legends for a much longer time. Fragments of its history are found in the old records left by the mission padres. San Gabriel Mission was established September 8, 1771, and two years later Captain Juan Batista de Anza left the Presidio of Tiebac, Mexico, to find a way to Monterey Bay. He came by way of the Salton Sea and San Gorgonio Pass, which he called "Puerto de San Carlos,"—or St. Charles Pass—on March 14, 1774.

When Anza came into the valley that the Indians called "Guachama," or "valley of plenty," it looked like a glimpse of heaven after the purgatory of the long leagues of the desert. He remained in the valley for two months resting and then went on to the San Gabriel Mission, where he described this "valley of plenty," marked by the mystic arrowhead, and advised the padres to take possession.

On May 20, 1810, Padre Francisco Dumetz hung some bells at the Rancheria of the Guachama Indians that they called Politana. The site is on the ridge north of Colton and is marked by a "Mission Bell" and tablet. It is about 100 yards west of the boulevard going to San Bernardino from the south.

In 1812, when the colonists of the east were having their second war with England, when old Chief Tecumseh was killed by the Americans in Canada, and when Napoleon was making his disastrous retreat from

Moscow, the valley of plenty was shaken by an earthquake so severe that the hot springs became fountains and the mud springs threw the hot mud fifteen feet into the air. The superstitious Indians were terrified and their medicine-men quickly laid the blame at the feet of the "Long-robes," as they called the kind padres. So the little mission was wiped out because the savages believed that the Great Spirit who made the mysterious arrowhead and lived in the hot spring was offended. A new mission was not established until 1820 and then at a point near Redlands.

The new mission had been established seven years—1820-1827—when a fur-trapper, Jedidah Smith, left Wyoming to come to California. He left the Colorado River at a point near where old Fort Mojave was built later, and traveled thence direct to the big snow-capped mountains (San Bernardino), crossed this mountain by Big Bear Lake and came to the arrowhead above the hot springs. He was guided by a member of the Shoshone tribe from Wyoming, who had heard of the springs.

The arrowhead inspired the Morman invasion, for during the war with Mexico, a Morman battalion under Captain Jeff Hunt built a log fort in Cajon Pass. It is well known that Hunt and at least two companions visited the arrowhead and the springs that lay below it.

Zion wished to establish a colony in California for the benefit of their recruits coming by way of the Pacific. Brigham Young had a "vision" of the rich land below the arrowhead, and in 1850 sent Captain Hunt to lead their colonists across the desert from Salt Lake. The colonists bought the present site of

San Bernardino from Sr. Jose del Carmen Lugo for seven thousand five hundred dollars, in September, 1851. When they laid out the town the street now called "D" was Salt Lake Street; "E" was Utah, and "G" was Nauvoo Street. They built a fort with palisades in the block between Third and Fourth, and C and D streets.

A trapping party was organized at Taos by Kit Carson and he appointed William Wolfskill and Ewing Young to come to California. They arrived in Los Angeles in February, 1831. They carried "serapes" and "frasadas" (woolen blankets) which they exchanged for California mules. The mules were so much superior to those of New Mexico that trading over the "Santa Fe Trail" started, via Cajon Pass, and the fame of the symbolic arrowhead spread clear to the Missouri River.

Robert Whitney Waterman was a co-worker with Abraham Lincoln in Illinois in 1854. He came to California and became the governor of the state. In the late seventies he purchased 600 acres around the famous arrowhead and built a home at the Steam Caves, in Waterman Canyon, and established a primitive "resort" at the hot springs. The writer had the privilege of being the guest of Gov. Waterman in 1880, at the springs, where we talked about Lincoln and the history of the arrowhead. In the same year I talked with the old Indians—most of whom talked Spanish—and they told me that the arrow was there "in my father's day, in his father's day, and long before that."

The Indians believe that the Great Spirit uses a great bow—the rainbow—and uses fierce, swift and

deadly arrows of lightning. The evolution of the well-shaped, sharp and perfect stone arrowhead took ages of time. At first stones were used as missiles but they had one defect: they could be thrown back by the opponent.

Then sharp stones were lashed to sticks giving the hunter a longer arm than his victim, and a stone that was not lost when the blow missed. Finally, the Edison of some tribe invented the bow and arrowhead, as great an achievement in those days as the highest power gun of today, for it meant mastery everywhere.

The stone arrowhead made man the conqueror of the brute world and the master of the less civilized savages.

While the history of the days of primitive man is a skein of tangled threads, gathered here and there by groping amid the fogs and mist of a speechless past, yet the stone arrowhead is surely proof of the existence of man, as the footprints in the sand were proof to Robinson Crusoe that he was no longer alone on the island.

Is it any wonder that the fame of this arrowhead on the mountain was spread among all tribes, and that it led so many to explore and develop California?

OUR HOT SPRINGS

Our hot springs are one of the great permanent commercial assets of the state. When developed into "Spas," or resorts, they attract thousands of visitors from abroad. When the waters are bottled they advertise this resource everywhere.

California has more hot springs of commercial value than any other equal area in the world, and most of them are just as valuable as the most noted Spas of Europe. They occur both in groups or as single springs, separated from the nearest neighbor by many miles. One of the most important of these groups is found in Southern California lying within a triangle formed by drawing a line south from Cajon Pass Murietta, thence along the San Jacinto Range to Palm Springs, and thence back to the Pass.

The geologic conditions within this triangle are unique and most favorable to study the origin, age and permanence of the hot springs, for these are matters of interest to everyone. This triangle is full of examples of the "old topography" of the early Tertiary times, that looks today very much as it did when the world was much younger.

The first thing noted is that there is a close relationship between the hot springs and the "faults" lines, or fissures in the earth's crust. The great fault belt that formed Cajon Pass cuts through the rocks of the mountains as three major faults and several minor ones. Near the south end of the Pass the belt branches like the strands of a brush, and the course of each

branch may be traced by the hot springs along its course as well as by the geologic evidence.

Of course in every major belt there are many minor parallel faults, and some at right angles, the crust of the earth being broken into great crustal blocks by pressure caused by the adjacent ocean bottom sinking or by mountain building. It resembles an ice-field cracked by being pressed against the shore. Our old earth is ever puzzling, but we know that ocean bottoms are sinking in some areas and lands are rising in others, and great cracks or faults are made in the crust that extends down some twelve or fourteen miles.

Hot rocks of different kinds, and even molten lavas still exist beneath certain areas. It is evident that if the rainfall soaks into the crust far enough to reach the hot spots the waters will become heated, and if they find their way back to the surface again they appear as hot springs.

This simple explanation, however, does not suffice for the great majority of California's hot springs, for some of these evidently see the light of day for the first time when they issue as hot springs, for they are the original waters of the hot rocks and lavas, and have no connection with the rainfall. Such waters are called "Juvenile" waters; while those derived from the rainfall, which sink into the ground to rise again at some lower level, are known as "Vadose" waters.

Vadose waters are characterized by fluctuations in amount, concentration, composition and rate of flow, because they are dependent on local conditions, such as seasons of abundant rain and seasons of drought. Juvenile waters, on the other hand, are constant in flow from year to year and do not change in composi-

tion or concentration. They also contain certain elements known as "deep minerals" and volcanic emanations, such as arsenic, boron, hydrocarbons and traces of rare metals; they are constant in temperature and flow excepting when increased temporarily by earthquakes, and some are radio-active.

Let us apply these definitions to the hot springs in the "triangle." The best known and most studied are the group of hot springs lying below the famous Arrowhead that are now being used by Uncle Sam for the benefit of our boys in khaki. These hot medicinal springs occur 1900 feet above sea level, and have temperatures as high as 202.2° F. They are distributed along a "belt" that is over 500 feet wide and three-quarters of a mile in length, extending from the Palm Spring on the east to the Steam Caves in Waterman Canyon; a belt that is nearly twice as long as the famous "strip" at Arkansas Hot Springs.

The formation of the belt is granodiorite and gneissoid rocks with some diorite porphyry. On the ridges the terrain of late Tertiary formations cover the ancient rocks of the belt, but its position is clearly defined by the patches of club-rush or bullrush—Sciopus occidentalis—locally known as "tule," and by the various forms of plant and flowers that have been stimulated into luxurious growth by the warm waters. Wherever ravines cut across the belt, hot waters and steam issue in a score of places and at all elevations from the top to the bottom of the ravines.

We know the amount and variations of the rainfall of the region, for the records extend back for many years; we know the composition of the waters, for they have been analyzed by many parties since Lieut.

Wheeler's report in 1876. A summary of the facts show:

1. That the flow has been constant, while the rainfall has been variable; and there is no apparent connection between the two.

2. That these springs are constant in composition and concentration.

3. These waters contain some boric acid, and just enough arsenic (0.5 part in one million) to make them of special value: iron, potassium, sodium, traces of lithia, and sulphur and hydrogen; and they are radio-active.

They do not contain the carbonic acid gas, nitrates, bromine and barium of the vadose waters. They are therefore classified as juvenile waters, or "rock juice" from the igneous rocks and lavas lying far below the surface.

Going down into the San Bernardino valley one finds some of the evidences of juvenile waters, but most of the springs are a mixture of both juvenile and vadose waters. This is natural, for in the valley they are overlain by some 1500 feet of sands, clays and gravel, and become mixed with the rainfall waters as well as having their temperature lowered by their passage through this covering.

The springs on the San Jacinto plateau are more evidently juvenile.

How old are they? Geologic time cannot be estimated in terms of years. They date back to the time when the great Cajon fault was formed; to the time when the "mountains were brought forth"; back to the time when these valleys commenced to gather the dust of tribe after tribe of primitive savages, and race

after race of human beings; to centuries too remote to be fully comprehended by the human mind.

Hot springs are long lived. Those of the Pass of Thermopylae in Greece, became famous when Leonidas defended it in 480 B. C., against Xerxes, and again in 276 B. C., when the Pass was defended against the Gauls. Today, the same hot springs are visited by curious globe-trotters.

The hot springs of California are a permanent asset for they will probably flow when the ruins of the ancient city of Los Angeles will be objects of interest, research, and wonder on the part of antiquarians of ages that lie hidden in the dim and far-distant future.

GEOLOGIC TIME

How many years ago was it that the Rancho La Brea animals roamed all over California? When did those saber-toothed tigers, camels, buffaloes and giant sloths cease to furnish a free circus to primitive man?

The answer cannot be stated in terms of years, as geology has no datum plane for measurements, no zero point; for it has no vestige of a beginning, no prospect of an end.

Some old men use the Civil War as their datum plane and their youngsters will use the World's War; just as the Romans dated everything from the founding of their city; and the Mohammedans date from the Hegira; and we write B.C. and A.D. in our histories.

Man in his superegotism measures everything in terms of his own body, and this has led to many absurdities. A mile is 5,280 feet and the distance to the sun is some 92,000,000 of miles, as measured in terms of a he-man's footsie tootsies. The California Indians think that the coyote created the earth; why not measure the distance in coyote tracks?

The "year" means one trip of our planet around the sun, and some men feel aged by the time they have made seventy trips; but if they had been born on the planet Neptune—which takes 175 of our years to make the same trip—the same man would be a puling infant only a few months old.

Geologic time cannot be measured in terms of the life of any human being; for geology applies equally

to the whole universe, while man is a mere microbe living on his speck of star dust lost in the infinities of space. Comparatively speaking, his life is brief, like the butterfly; and physically he does not amount to more than the speck of dust caught on the tip of a flea's eyelash.

In the study of astronomy one gains new ideas of time and distance and no longer thinks in terms of feet, but in terms of millions of miles, or light years; and it should be remembered that geology is not a fixed science, like astronomy and mathematics. At present geology simply uses the facts of all sciences to study the history of the earth. It is a young and growing youngster and as such is very often troubled with growing pains.

Geologists are constantly hunting for a datum plane. They have tried calculating by the sediments carried to the oceans by the rivers, with results that vary from 70,000,000 to 6,000,000,000 of years. Others have tried to figure out the rate of cooling, the effect of tidal retardation, the heat of falling meteors, the loss of solar radiant heat and radioactivity; and from all this data the age of the earth has been summed up as from 10,000,000 to 6,000,000,000 years old.

Some progress has been made in the case of the very recent gorge of Niagara Falls, which was cut after the glaciers had receded; but the estimates of the length of time used in cutting it vary from 10,000 to 200,000 years; the majority being in favor of the 10,000.

Primitive man lived in the Glacial Age, but the records of mankind extend back only 5,000 to 8,000 years. The Sequoia, or big trees, once grew abundantly in various parts of the East and are still living in California.

The glaciers did not quite reach down to the big trees at Wawona, where some of them are over 5,000 years old; in fact, living when the Egyptian ruler Tut-Ankh-Amen was a kid.

Geologists are busy trying to correlate all of these kinds of diverse data, and the next generation may have some relative estimates; but for the present the common people are content to place the question of geologic time in the pigeon hole with "How old was Ann?" and "Who struck Billy Patterson?" or content themselves by saying, "Once upon a time," or in certain geologic "periods."

CALIFORNIA GLACIERS

California has eleven living glaciers still at work in the shadow of the peaks which are lingering remnants of the "Glacial Age," that great winter of winters.

While they are "remnants" as compared with the ones that existed here formerly, they are by no means insignificant, but present all the perils of crevasse and avalanche that have made famous the Mer de Glace on Mont Blanc.

Glaciers occur on mountains or plain, where the snowfall in the winter exceeds the melting during the rest of the year; for glaciers are only long streams of closely compacted snow crystals from snows that have been falling for hundreds of years. Century after century the snows piled higher and higher, packing and freezing into ice until at last a mighty glacier began to slip down, pushing loose rocks and boulders to right and left and in front forming "moraines."

Local Cause of Glaciers

The local cause of the glaciers in California was the rejuvenation of the Sierras, at the beginning of the Pleistocene period, when the lofty peaks reached the magnificent height of 20,000 feet. At the present time the highest crests are about 14,000, showing the effects of the erosion.

The Black Mountain Glacier was discovered by John Muir in 1871 and lies at the head of the Merced River. It is short now, but its ancient path is clearly marked by magnificent moraines that extend in majestic curves towards Yosemite and were a factor in smooth-

ing off the rough edges of that mighty canyon and in giving it the "U" shape.

The Maclure Glacier, near Mt. Lyell, 13,090 elevation, is about a mile long and the same in width, and is the source of the Tuolumne River; which is turbid at first with the silt ground by the moving ice. Stakes set show a movement of one inch a day; a slow progress when compared with the Muir Glacier of Alaska that moves five and ten feet a day. One can tell that it is living and moving by noticing the fine gray mud, like that from a grindstone, in the waters that flow from them.

The Mt. Rittier Glacier at the head of the north fork of the Owens River is one of the sources of the Los Angeles water supply; a fact not generally known, but very suggestive.

Near Mono Lake on Mt. Dana, Mt. McCloud, and at the head of Parker Creek are glaciers, each one of which would be advertised and talked about if it were in Europe.

Five on Mt. Shasta

The finest group of glaciers is found on the "grand old mountain of California," Mt. Shasta, 14,380 feet elevation.

The five glaciers still bear the names given by the native Indians, excepting one, which bears the name of the first state geologist, Prof. Whitney. The Whitney Glacier is over two miles long and ends at an elevation of 9500 feet. The Bolsam Glacier, or Big Glacier, is over two miles long; and the Wintum Glacier—named for an old Indian chief—is nearly as long.

The Hotium, or steep-rock glacier, and the Konwakiton, or mud glacier, are the shortest ones.

These Shasta glaciers are warranted to give the Alpine climber all the thrills, dangers and scenic effects that one expects in the European ones that are written about and talked about so much. The white snowfields are the abode of unrelenting frost, the great blue glacial ice reflecting the sunbeams in exquisite tints of opal, pink and green, and contrasting shadows of deep violet blue. There are snowfields colored by a microscopic alga—Sphaerella nivalis—where one may walk in the "red snow" and leave crimson footsteps. One can hear the smothered thunder of the avalanche, see the smoke of its path and listen to the bursting of its fall. The visitor will have to use the ice-pick to cut steps as he wends his weary way past some deep and yawning crevasse.

All the glaciers need is advertising. This is a good chance for some young man to start a "Why-Go-Abroad" club and engage some sturdy Swiss yodelers to sit around and look picturesque; a "speed law" to insure safety and insure the sale of special boots with square-headed nails in the soles, and alpine stocks with the names of the glaciers already branded, and a lot of strong ropes. Climbing the glaciers would soon become a fad.

Ancient Glaciers

The proofs of the existence of former glaciers in California are many. Bare granite slopes showing polished rocks—the most evanescent of all records—are still found in irregular patches that reflect the sunbeams like glass, as at Vernal Falls in the Yosemite.

They mostly occur at elevations of 7000 to 9000 feet, but a few patches are found as low as 3000.

Glacial grooving and scratching are common in all regions near the crests of the range.

The best evidence and the one most easily recognized are the lateral and terminal moraines formed by the great glaciers as they plowed through the soil and softer rocks. Many of these are from 100 to 200 feet high and nearly as regular as an artificial embankment and are found at elevations of 2,000 to 5,000 feet. They are composed of rough, angular, not water-worn boulders of all sizes, mixed with sand and finer detritus, and commonly covered with a forest growth.

These moraines afford a means of mapping the course of the glacier and estimating its thickness.

One of the glaciers in Tuolumne county was at least forty miles long, with a depth of from 3,000 to 4,000 feet.

There were many huge glaciers at the heads of the Merced, Tuolumne, San Joaquin and Kern rivers; and nine old glaciers have been mapped in the Mono Lake basin.

They were gigantic, slow-moving ice-plows that changed the upper canyons of the rivers from "V"-shaped into the typical "U"-shaped form. These heavy ice-plows carved the upper canyons of the Yosemite and plowed out the basin that Lake Tahoe rests in.

Glacial Lakes

The heights of the Sierras are dotted with lakes of glacial origin. They lie embossed in the deep woods, high on bald table-lands and around the feet of icy peaks, in basins formed by the morainal dams or scooped

out of the rock. Lake after lake, some round or oval like mirrors, others narrow and winding like silver zones. From the summit of Red Mountain no less than forty-two can be seen in a radius of ten miles; and in Lake Hollow, just above Tuolumne Canyon, ten lakes lie in a hollow like eggs in a basket. There are over 1,500 glacial lakes already mapped in the high Sierras, nearly all being on the western slope.

Many small glacial lakes have vanished, being changed by filling into bogs and meadows. "Hanging Meadows" often occur on morainal soil aslant on the hillside.

The agricultural value of the glacial soils needs no argument when it is recalled that they are the dominant soils from Minnesota and Wisconsin through a belt that extends along the Great Lakes from Illinois to New York.

Interglacial Epoch

There were two major periods of glaciation with an interglacial time as shown by the records, especially those of the terraces along the shores of the extinct Lake Lahontan that filled the western part of Nevada and extended into a portion of our state. There were several minor glacial advances differing in severity; alternating with warm periods when the icefields retreated towards the crests, giving climates even milder than that of today.

Plants and animals which naturally belonged farther south have been found between the layers of glacial debris, showing that the milder interglacial climates caused immigration to the north.

The older animals of the Rancho La Brea, the saber-toothed tiger, giant sloth, camel and others, date

back to such times; and there is abundant evidence that primitive man existed then.

The second return of the glaciers seems to have been the most severe and prolonged, as shown by the records of Lake Lahontan; and this may account for the extermination of the gentle (?) saber-tooth and his comrades.

How long ago did this occur? Day before yesterday, in geologic terms. We know only a few facts about the "date": such as that the glaciers stopped just before reaching the Wawona grove of big trees; and some of them are over 7000 years old, according to botanists; that the caves in the limestone of the Pit River Canyon are high above the present channel and contain some of the same animals as Rancho La Brea. We also know that we are living today in the last vestiges of the Glacial Age of California; possibly entering another interglacial epoch.

The geologist of future eons may find some interesting relics on the site of the City of the Angels.

THE SIERRAS

The huge Sierras are the dominant physical feature of the state and are the most imposing and the highest group in the United States. They are our skyline guardians controlling the climate and giving the state its many special charms.

They affect the climate of many other states, as they turn the icy blizzards from the polar regions, sending them eastward.

The snow-clad summits cool the moisture-laden clouds from the ocean, storing the waters in snow-banks to feed the thirsty crops in the summer time, and furnish the electricity—the "white coal"—that warms and lights the houses and turns the wheels of thousands of industries.

On their slopes are found vast forests of giant pine and redwoods; on their flanks are the rich ores of the Mother Lode; and their stupendous canyons are lined with the highest and most majestic waterfalls in the world that are the mecca that attract new thousands every year.

The Sierras include the Sierra Nevada, Klamath, Sierra Madre, San Bernardino and San Jacinto ranges; for these all date from the Jurassic times; while the Cascade ranges, with Mt. Shasta, date from the close of the Cretaceous; and the Coast Ranges are still later, dating from the middle Miocene. They stand as a towering and almost impenetrable wall along the eastern boundary of the state, for there are only five passes in a length of 160 miles, and only three of them are in use.

"Eternal Hills"

We speak of "the everlasting hills" and "the eternal mountains" because they seem so when compared to human life; but geology has rediscovered the fact that mountains are born, and there was a time "before the mountains were brought forth"—Psalms, cx, 2. Like everything else in the world, they are born, reach maturity and finally pass away; just as the pre-Cambrian Taconic Range of the East has nearly vanished; and like the Alleghanies of Carboniferous Age are now mature mountains, smooth and rounded; while our Sierras are young and therefore rough and rugged.

These Sierras contain the highest peaks in the United States, culminating in Mt. Whitney, 14,501; but there are fifteen others that rise over 14,000 feet; thirty over 13,000; forty over 12,000; forty-eight over 11,000; seventy-five over 10,000, and 120 over 9000—certainly a bewildering array for a single state.

There are seven living, moving glaciers on these mighty crests that are sluggishly crawling rivers of ice, with huge moraines; while the glacial lakes are too numerous to count.

The drainage is nearly all down the long western slope; and the rivers have cut tremendous canyons from 1000 to over 2000 feet deep. The material eroded has filled the great valley to a depth of over 1500 feet. These ranges are the only ones not cut by a river that rises in another state.

The core, or backbone, of the ranges is mainly granite rocks that have welled up and solidified into gigantic mass or "batholith." There is some evidence that an "ancestral range" may have existed in pre-

Cambrian times, along the site of the present mountains. The rocks exposed include sediments and igneous rocks of every age from the Carboniferous to the end of the Jurassic; also igneous rocks and lava flows of more recent date.

The Sierra Nevada

The geo-history, in brief, is as follows: the foundations of the Sierra Nevadas were laid down in a great trough, known as "the Sierra-Nevada geosyncline," which began in Silurian times. The shallow Jurassic, or Logan, sea covered all of California and extended into Nevada as far as the 117th meridian; and its sediments accumulated in this great trough and also spread out to the west.

At the end of the Jurassic times the Sierras were born, the long cycle of deposition being interrupted by an intensive and extensive cracking of the earth's crust along great "fault lines."

The floor of the Pacific Ocean sank, causing heavy pressure from the west and southwest. Under this pressure a great arch was lifted up by the intumescent lavas below that reached clear from the Sierras to the Wasatch Mountains of Utah. This arch finally broke down into tilted blocks—monoclines—that readjusted themselves into long mountain ranges and sunken valleys.

The great Sierra Nevada is simply a great block of the earth's crust tilted to the west. The eastern face, or edge, of the block is easily studied from the Owens Valley at an elevation of about 5600 feet. Looking west the Sierras rise sharply over 8400 feet higher; while the summits are only ten miles away in

an air line; but from the summits the tilted block slopes gently toward the great valley, 150 miles distant; and only about 400 feet above sea level.

The Sierra Madre

The Sierra Madre is a similar tilted crustal block, as anyone may see at the summit of Cajon Pass. It is only a short distance from the desert to the summits; while the descent to the south is long weary miles.

The long periods of the Cretaceous and Tertiary passed during which these tilted blocks, or mountains, were eroded and worn to low levels—"peneplaned," but at the beginning of the Quaternary—"the Sierra Epoch"—the Sierras were rejuvenated, or reborn. This rejuvenation lifted the crests to the towering heights of 20,000 feet. On such heights more snow would fall than could be melted in the summers; and this increase of hardened snows formed the glaciers and brought on the Glacial Age in this state.

These lofty summits have been worn down from 20,000 feet to 14,500 feet and the glaciers have almost vanished; so that we're living today in the last of the Glacial Age.

During the mountain building minor "faults" were formed deep enough for the hot waters from the igneous rocks below to flow upward. These hot waters were heavily charged with various minerals and metals in solution, and as they cooled in their upward passage they formed the "veins" worked by the miners. During the erosion of the ranges the tops of many of these veins were worn away, liberating the gold that was washed into the streams, forming our "placers," but that is another story.

In future epochs these ranges will all be worn down again until they form almost a plain, or "peneplain," and again they may be re-elevated to greater heights, bringing on another Glacial Age.

The earth is ever old and ever new. It never remains at rest and in quiet for long. In this way coming man will find a new earth with new soils and new resources freshly prepared for his use and enjoyment.

THE COAST RANGES

The Coast Ranges, which form the western rim of the great valley, are wholly different in origin and structure from the Sierras. They are composed of rocks which have been bowed up into great arches or anticlines; while the Sierras are great blocks of the earth's crust that are tilted to the west.

They are not a single range, but a chain or system of ranges that are approximately parallel to each other and to the coast, with narrow valleys between them.

Most of those south of San Francisco have a height of only 2000 to 3000 feet; but at Tejon Pass they rise to 5000 feet or more above sea level.

They are largely covered with good timber in the northern ranges, but in the south they are either covered with heavy chamisal or nearly naked.

While they contain a few small gold-bearing veins and one or two places are worked as placers, they are famous for their great deposits of quicksilver, chrome iron, magnesite and diatomaceous earth. Some coal of Cretaceous and Eocene times is mined, but not extensively, as they are light coals of the lignite class.

Owing to their arched anticlines the Coast Ranges of the southern part of the state contain the vast reservoirs of petroleum that are known the world over and now overshadow the gold production.

Near the close of the Cretaceous and in the first half of the Tertiary shallow seas extended across the great valley to the base of the Sierra Nevada and across the southern plains to the base of the Sierra

Madre. As the mountains rose abruptly from the shores of these shallow seas sands covered the bottom near the shore, while muds were deposited further out. These muds of the ancient sea bottoms supported a rank growth of various kinds of organic life, such as seaweeds, diatoms and fishes. The decomposition of this organic matter under sea water, shut out from the atmosphere and exposed to lime, is supposed to be the origin of the petroleum.

The ancient muds hardened into shale, and when those old sea bottoms were slowly and gradually bent upward into ranges the oil, gas and salt water separated, forming the "oil pools" of today.

Geologic History

Before the present ranges were uplifted there was an ancestral range that formed a chain of islands, reefs and banks in the ancient seas. These islands were composed of pre-Cambrian rocks which were largely igneous in character. The granite bosses of San Luis Obispo County, granitic masses in the Santa Lucia Range and similar small patches in Santa Cruz, San Mateo and Marin counties mean that there was a narrow ridge of land, or separate islands, marking the course of the present ranges, along definite fault lines. It means also that these "faults" were established at a very early date and have been opened and closed again and again at "critical periods" in the geo-history of California.

The present ranges were uplifted at the close of the lower Miocene, just after the Monterey sediments had been deposited. At that time there was a sinking of the sea bottom far off shore, accompanied by a thrust

or pressure to the northeast, bending and bowing up the strata and folding them into a series of parallel ridges and valleys.

This was not done suddenly, all at one time, but was a gradual, yet persistent, pressure, like that of the coastal rising of the present times. It was also largely local in its action. Some areas are sharply arched and folded, or badly faulted, leaving a complex structure. Others were pressed so slowly and steadily as to form broad and gentle anticlines, such as those of the oil fields of the San Joaquin Valley.

The Coast Ranges were heavily eroded up to the end of the Pliocene; but in the Pleistocene they shared the general uplift when the Sierras were rejuvenated and averaged some 2000 more feet in height than they do today.

Like the Sierras, they have lost this height by erosion, the sediments loading the bottom of the sea to the west; and in the course of years to come these ranges may again be re-elevated, or another range may appear along the line of the California islands, as outlined in a recent article.

The old earth is never in a state of complete rest. It is ever true that, as the prophet said, "the mountains go up and the valleys go down." Psalm civ, 6.

When a load is taken off the mountains and piled onto the sea bottom, nature begins to establish an equilibrium again, for she has "weighed the mountains in scales, and the hills in a balance." Isaiah iv, 40.

Is it not wonderful how geologists are rediscovering facts known to the prophets who lived before King Tut-Ankh-Amen was born?

THE GREAT VALLEY

Thousands of people from the East will travel through "the Great Valley of California" for the first time this spring; but most of them will have only a dim idea of its extent and value to the state and to the nation.

The valley is a level-floored depression more than 500 miles long and from twenty to fifty miles wide. It includes both the San Joaquin and Sacramento valleys and has an area of 18,000 square miles. It alone is larger than Denmark—15,289; Holland—12,648; or Bosnia—16,206. It is larger than New Hampshire and Vermont together. It is a vast plain without rock outcrop or terrace; with sluggish streams; and even tidal sloughs at one point.

It is canoe-shaped, with only a notch in the rim to let the water spill out.

Along the sides are uplands of sloping plains or "alluvial fans," reaching to the foothills; but the elevation of the floor varies from tide level at the notch in the rim at Carquinez Straits to 100 feet at Marysville Buttes and 800 at Redding; while the elevation at the south end is 420 feet at Bakersfield.

Fenced by Mountains

The Great Valley is as well fenced in as a great ranch. On the east rise the Sierras with elevation from 12,000 to 14,000; while to the west the Coast Range forms a series of parallel ridges of moderate height; inclosing many narrow valleys, like the Salinas Valley. At the north Mt. Shasta and the Cascade Range form

the inclosing wall; while the south end is closed by the Coast Range joining the Sierras.

The only access to the valley is by mountain passes such as those that the railroads crawl up. The Livermore Valley, near the center of the west rim, gives the drainage a gateway to the Carquinez Straits and thence into San Francisco Bay. The combined flow of the San Joaquin and Sacramento rivers discharges through this low opening in the bay and thence to the ocean through the Golden Gate.

The drainage into the valley is mainly from the Sierras on the east side; the total discharge amounting to some 12,000,000 acre feet. The streams from the Sierras have large watersheds, long courses and flow from the highest range in the United States where the rainfall is heavy and the snows are deep.

The streams from the Coast Range are either not permanent or small and erratic and of much less importance than those from the east side.

Notch in the Rim

The "notch in the rim" or present outlet to the ocean is of very recent origin, being more recent than the Glacial, San Pedro or even the Terrace epochs, the date of the opening being known as the "Golden Gate epoch," or the time of the submergence of the drowned harbors along the coast. Indian traditions extend back to that time.

In earlier geologic epochs several rivers crossed the Great Valley to the ocean; but their courses are buried deep under the sediments of the valley. We only know of their existence by tracing their former courses through the Sierras, and by the submerged channels

cut as deep canyons in the bed of the ocean. These ancient rivers were especially rich in gold that will be given in "another story" under the title of "Ancient or Lost Rivers."

Great Valley's Origin

The origin of the Great Valley is notable, for the normal valleys of the United States are formed by a stream wandering back and forth, and the valley is "V"-shaped, due to the meanderings of the stream, whereas the valleys of California are mainly the direct product of crustal movements and occur as sunken blocks.

This valley is a great structural trough—tectonic trough—in which a series of sediments have accumulated from the earliest Cretaceous times to the present.

As the rocks of the mountains that inclose the valley became weathered the rock particles were carried down into it by the rains and determined the character and quality of the soils. This explains why over 500 different kinds of soils are shown on the maps of the "soil survey," each especially adapted to best raise certain crops.

The valley was a marine sea during the Eocene and up to the Middle Miocene, when the Coast Ranges were born. During the rest of its history it was a great bay, or series of lakes, with salt water filling some; while others were brackish or fresh, as shown by the fossils in the sediment.

There is little diversity in the physical aspect of the Great Valley, the differences between the north and south being largely climatic.

The most striking features of the valley are the "alluvial fans" and aprons which border the edges. The apex of a "fan" is at the mouth of a canyon, for the fan is simply the material dropped by the stream when it emerges from the canyon.

The Kern River has formed a delta-fan that has grown westward, reaching the McKittrick hills and isolating the Buena Vista basin to the south. On the other hand, some of the streams in the Sacramento drainage have cut trenches deep into the valley floor.

The Great Valley is a self-sustaining empire of itself surrounded by mountains that are not only covered with the mighty monarchs of the forest, but are also filled with rich mineral deposits unequaled in value and diversity by any other equal area in the world.

YOSEMITE

The first glimpse of Yosemite is a vision that silences one with awe and reverence. It is a valley full of motion, full of the majestic and sublime, full of gorgeous splendor; a land of enchantment with a fairy-like quality, in spite of its immensity.

Waters are falling in ribbons, cascades and rivers. The crystal streams that leap over the stark precipices seem mad with joy and shout as they fly to join the songful Merced. The cascades roar thunderously as they leap over the purple-colored, lichen-stained granites and dazzle, confuse and charm one as they ravel and knit their waters into webs of mist.

It is a matter of unceasing wonder how nature has combined so many marvels in a canyon that is only seven miles long by less than one wide, and a half-a-mile deep.

The highest falls in the world are found there, for the highest in Europe is the Staubbach, in Switzerland, which drops 980 feet. The Yosemite Falls has one clear leap of 1,500 feet and a total descent of 2,350 feet, or nearly half a mile. It is equal to eleven Niagaras piled on top of each other. The Virgin's Tears, or Ribbon Fall, has a sheer drop of 1,612 feet; while the Widow's Tears drops 1,170—make your own wheeze about this.

All the falls have a greater volume of water and are set in the midst of loftier precipices than any foreign ones.

Each has its special charms as: the dainty, fairy-like form clothed in white robes of Nevada Falls; the

Vernal Falls, strong bodied and massive; and the wind-blown tulle of Bridal Veil.

While one wonders and admires he can also note many geologic facts of interest, such as: the falls are perpendicular because of the hardness of the granodiorite and the brief time that has elapsed since a gigantic glacier occupied the valley.

The Granites

The Yosemite offers an exceptional field to study the granitic rocks, mostly granodiorite, for they occur in peaks strangely grouped, in isolated peaks, in needle-like pinnacles, smooth domes or as majestic vertical walls.

In places the granite rocks have peeled off along the concentric joint-planes, as the layers of an onion may be peeled off; and curved lines, arches and domes have been the result.

El Capitan, that guards the entrance to the main valley, is not a captain but a field marshal of the rock world. It shoulders the sky 3,604 feet above the floor of the valley, more than twice as high as Gibraltar, while it would make King Arthur's Seat—822—or Dover Castle—469—in England, look like pigmies. The very top alone covers 400 acres of naked granite. This giant is composed of granodiorite in which the joint structure is but feebly developed.

The Royal Arches, of 2,000 feet span, are recessed curves in the granite front. Here the granites are divided into parallel concentric rings, the layers being from one to three feet thick, with vertical joints at irregular intervals.

The peeling off in concentric rings—"exfoliation"—was helped by the presence of the joints, as well as by the plucking of the glaciers. This exfoliation of the granites, in many places in the region, is apt to be deceptive, giving smooth surface slopes like those worn by the glaciers.

Half Dome is 4,892 feet above the valley floor and looks like a mountain cleft by some gigantic scimitar. It is called Tissack by the Indian, for the squaw that was turned into stone by an angry hubby; but geology, taking no account of domestic troubles, says it was formed because it was bisected by a vertical fault-plane and one-half fell off during some heavy earthquake.

Liberty Cap, 3,112 feet above the valley floor, is a fine sample of exfoliation; and so is Cathedral Rock, 2,591, which alone would dwarf the noted Duomo at Florence, Italy.

The granites show many ancient fault lines, besides "The Fissures" where the clefts in the rocks are only about four feet wide, but many hundreds of feet deep. This lends weight to the theory that the beginning of the valley was the sinking of an elongated crustal block when the Sierras were uplifted and the Merced River followed the depression.

River Work

As one travels by auto up the Merced River it is seen that the lower stretches of the canyon, where the stream cuts across the "green-stone" ridges of the foot-hills, are "V"-shaped with uneven slopes covered with soil and rock debris. The green-stones are of Jurassic Age and Mariposa formation, and near their contact with the granites the slates and schists become

harder and contain hornblende. It is notable also that the veins of granite extend into the altered slates and schists, showing that the granite intrusion is the more recent; therefore, the geologist dates the origin of the Sierras at the close of the Jurassic after the Mariposa sediments had been laid down.

At El Capitan the canyon becomes typically "U"-shaped, which means glacial work, and not simple stream erosion. The river did much of the work, but during the preglacial times the Yosemite was not as wide or deep or sheer-walled as it is now; for the river ran not far below the present top.

The uplift of the Sierras was not sudden, but very gradual, and in two major stages, with an interval of long rest in between in which the top of the present gorge widened into a flat-floored valley.

The second uplift caused a slipping along the fault lines forming a series of steps in the upper canyon, as well as deepening the main gorge. On each step is a rock-rimmed basin, or tarn, and the streams fall from one giant step to the other, as at Vernal and Nevada falls.

The streams of today still flow in shallow channels, with gentle gradient on the uplands that are flat hanging valleys, until they make their dizzy leap into the Yosemite.

The Glaciers

There is no doubt about the glaciers, for the old cirques seen on the tops of the mountains and upper slopes around Yosemite are marked with lateral moraines that define the courses of the ancient rivers of ice as clearly as fences would.

There are "roches moutonnes" or rounded hummock-like forms, like the backs of sheep in a flock, that are elongated in the direction of the canyon. There are bare rock surfaces polished, scratched, striated and fluted or grooved.

There were a number of glaciers at the head of the Merced River. The Maclure Glacier on Mt. Lyell—13,090—is still a living glacier about one mile long that has all the essential features of its ancestors. The Black Mount Glacier has magnificent moraines extending in majestic curves toward Yosemite. The great glacier of the Tuolumne Meadows, that was forty miles long, sent one branch down the Hetch Hetchy and the other down Tenaya Canyon, converting it into a typical glaciated gorge where the cascade spreads out over glacier-polished rocks.

The glaciers from Tenaya, Little Yosemite and down the Illilouette converged into one grand main ice stream 3,000 feet thick that swept down the Yosemite Canyon, carving and plucking at the rocks and converting the canyon into the "U"-shaped type. It terminated near El Capitan, where the end of the advance is seen in a large terminal moraine, a lunate ridge spanning the canyon. The Three Brothers, Sentinel Rock and some other points were above the top of the glacier; and the glaciers to the south did not extend down as far as the Wawona grove of big trees.

At the retreat of the glaciers the Yosemite floor was left clean and bare and a lake soon formed behind the morainal dam near El Capitan. It must have been a beautiful lake reflecting the towering precipices with transcendant waterfalls.

Since that time the sediments have filled up the lake and now the Merced River sings its winding way through the tarn. Ages passed and the Indian appeared in Ahwahna, the "deep grassy valley," where the great grizzly bear, "Yosemite," roamed. Finally the white man came, at first in driblets and now by the thousands.

Today the "efficiency experts"—not "tightwads"—are making an economy run, showing how to visit with least expense this marvel of marvels, the Yosemite.

DEATH VALLEY

Now is the time to visit Death Valley, for in the summer time the extreme heat may make it dangerous.

This valley has been unknown for years, except to the few; and the unknown is ever surrounded with mystery out of which grow legends, fictional romances and stories that outrival Munchausen. Today the valley is no longer a mystery, for the kindly signs of the Automobile Club of Southern California give plain directions to the life-saving springs; and autos travel the lonely trails, robbing the region of some of its terrors.

Having travel repeated over the region in charge of survey and geologic parties, some of the errors can be corrected and false impressions removed.

Death Valley is the sink of the Amargossa River—Spanish for "bitter river"; and lies mainly in Inyo County, but curves south into San Bernardino County and then recrosses the line to the north, giving the valley the shape of a fish hook.

It is about 175 miles long to the northwest and from eight to twenty-five miles wide, lying parallel to the Sierras. Mt. Whitney is 14,507 feet above the sea; while Death Valley is, in one place, nearly 400 feet below sea level; making the highest and lowest points in the United States only sixty miles apart, in an air line. The bottom of the valley is also 1,000 feet lower than the bed of the Colorado River at the Grand Canyon. The valley is bordered on the west by the Panamint Range, culminating in Telescope

Peak, over 10,000 feet high; while the Funeral Range, of over 7,000 feet elevation, forms the eastern border.

The valley's lugubrious name came because a party of emigrants from Utah tried to cut across-lots with ox teams. This display of the "valor of ignorance" cost the lives of most of the party.

* * *

No two persons will receive the same impressions of the region for those will vary according to the health, temperament and education of the traveler. Coming over any one of the passes one looks into a vast, stark valley that is a hazy gulch, immense, unreal, weird and full of color. It is the abode of silence and loneliness; the majesty of simplicity and desolation. It is one of the far-away, lonely places of the earth; naked, sinister, sombre; where the gruesome and the beautiful, the tragic and sublime go hand in hand.

Seen at sunrise the tips of the Panamint come out in silver with flashes of red on the snow; while the ravines below are a dark purple or black. At sunset it is the valley of the shadow of death, over which float gray and silver-edged clouds; while the mountain slopes are covered with a ruddy brown haze; a gray mantle that slowly darkens into purple gloom that suddenly turns black; then the stars come out and sparkle like diamonds in the black sky.

"The sun comes up like thunder"—a la Mandalay —and with the sun comes the hot wind and quivering heat. In the summer time this heat is dangerous as it dries up the blood and tissues, and at that time it is impossible to walk any distance for one simply cannot drink water enough to sustain life. In the shade it is bad enough, for the thermometer often marks from

120 to 130 degrees; and as large areas of the valley are below sea level one must have a good heart and lungs, in fact, be in perfect health, in order to stand the heat and the dense atmosphere.

Sometimes furnace-like gales sweep through the valley, giving a dust storm, a smoky, weird, murky hell where the sun is but a disc of dull copper set in a pall of gray dust, while "dust devils" whirl dizzily on the barren flats.

The winter months are the only proper ones in which to visit Death Valley, for at that time the days are delightful, but the nights are bitter cold, and the range of temperature is extreme—95 in the afternoon and zero by five o'clock in the morning.

The air is remarkably clear in the winter, making objects many miles away seem close at hand; but in the summer time photographs are hard to get in the dusty, quivering air, and the mirage may give strange and distorted effects.

* * *

A study of this geologic section gives the history of the great valley. The Cambrian and Ordovician limestones were deposited in ocean waters free from sand or mud, and at some distance from the ancient land mass known as "Cascadia." The land mass sank again and was covered by the waters of the Pennsylvanian Sea, in which more limestones were deposited.

At the close of the Jurassic period there was a tremendous breaking up of the crust of the Great Basin, clear from the new-born Sierras across to the Wasatch mountains of Utah. This cracking of the crust was accompanied by heavy pressure from the west, tilting the huge crustal blocks just as ice floes

are jammed and tilted along the shores of the Arctic Ocean.

These tilted blocks form the "Basin Ranges." Death Valley was at first one of these "sunken blocks" and as such become at once the catchment basin of the surrounding region. Today it is the catchment basin or sink of the Amargossa River.

Death Valley became a great salt lake, for all the streams flowing through the desert dissolve mineral matter and carry it into the sinks which have no outlet, and where the evaporation is enormous; finally leaching the mineral as a coating to the "dry lake." It is easy to see how the feeding waters would bring salt, gypsum and the alkalis to this great sink; and how alternating cloudbursts and sand storms would cover the minerals with mud or sand.

The origin of the borax, however, is very different. There were volcanic outbursts at different times in the life of this lake; and the lavas carried boric acid. In the Eocene there was a flood of rhyolite and andesite lavas; and in the Miocene there were flows of basalt lavas. When such a red-hot stream of lava flowed into this saline lake there were many chemical reactions. Among the things formed was the tetraborate of soda, or borax, as it is more familiarly called.

The desert plant life, the animal life, the few poison springs are other stories that will intrigue the traveler.

Death Valley is a storehouse of raw minerals and mankind has only to turn the key. The amount of these riches is vast because this sunken block has been for untold ages the playground of Father Time.

WHY THE DESERT?

The traveler in the auto or in a Pullman turns his weary heat-tormented eyes away and asks, "Why the desert?"

Has the desert a place in the economies of nature?

What worth-while work does it do?

It may surprise some to know that a desert is just as necessary to a nation as a cook stove to a home. That is why deserts form one-fifth of the entire land surface.

HEAT.—The first thing the visitor notices is the heat. Not so much the direct heat of the sunlight as the radiated heat from the hot sands; and the glare, because there are no dark shadows, dark colors or green foliage. The air is cool and crystalline in the mornings, but it may be like the scorching breath from a fiery furnace in the summer. I have noted 146° F. in the sun and 128° F. in the shade in Death Valley. On one Christmas day it was 94° F. at Saratoga Springs in the afternoon and four degrees above zero at 5 o'clock the next morning.

The intense heat of the desert makes the thin air rise rapidly, leaving a vast vacuum below that must be filled with colder air from without. It draws cool air from the ocean, creating the land breezes that realtors write about as "the glorious climate of California."

MOISTURE.—The evaporation on the desert is enormous, for it measures, by government tests, from ten to twelve feet, in some places; while the rainfall

is from nothing to five inches in general; with a few localities that have as high as ten inches.

This rainfall is spotted, irregular and intermittent. One spot may have no rain for a year or more and then get a cloudburst; a torrent of water sweeping down the side of the mountain. The cloudbursts cut gullies and canyons, giving the impression to many that this region once had large rivers, creeks and lakes. This is an error, as the desert has been very much like it is now for untold ages; at least as far back as the time when the Sierras were born (Jurassic Age).

The rivers have their bottoms on top as a rule, and live by concealment, except where a reef of rocks brings the waters to the surface. Most of the lakes are intermittent, filling up after a rain and then drying up into a playa. The springs occur mostly on deep "fault lines"—cracks in the earth crust that are miles deep—and the water comes from distant sources.

The plants, like the mesquite, have deep exploring roots that hunt moisture at depths of fifty feet or more. Many plants store moisture in their pulpy masses for months. Few desert plants have large leaves and these turn edgewise to the sun. Many of the animals are nonperspiring. The horned toad and lizards are thought by some to be descendants of the monster Saurians of the Cretaceous Age; or evolution with the reverse English. The toads soak up water like blotting paper when put into it.

Winds.—The winds rush like water through the least obstructed passes in the mountains; and are ever-biting, grain by grain, at the hills until they crumble and are blown away as sand. They scour and polish everything from hills to boulders. At night

when the sun goes down the winds cease to blow and it grows bitter cold.

SAND.—Every day in summer one can see sand whirls, mad columns of sand from 100 to 2000 feet high, whirling dizzily as they stalk slowly and silently across the plains. Wind-driven sand, like breakers on the beach, climbs the mountains as if to overwhelm them. The sands are heaped in mounds and dunes crested like driven snow. The wind and sand form a cutting sandblast that produces curious, fantastic and weird effects: faces, columns, spires, turrets and monstrosities that are the sport of the winds.

MOUNTAINS AND VALLEYS.—The desert is traversed by mountain ranges of a peculiar structure. Imagine the surface of the desert fissured by great cracks ten or more miles in depth; under pressure long blocks of the desert were tilted up along these fissures, or faults, like ice cakes along the shore.

In this way the mountains have one sharp, nearly vertical face and slope gradually into the desert on the other side.

The valleys are the portions lying between the mountains like great bowls, *with no outlet.*

DRY LAKES.—The rain waters dissolve minerals in the mountains and carry them into these bowls, forming a lake for a few months and then evaporating. These intermittent lakes become vast beds of soda, salt, gypsum, borax, potash, strontium and other valuable minerals. Within 200 miles of Los Angeles the desert contains vast treasures of over seventy-five known minerals of commercial value; for, besides the "Dry Lake" deposits, there are mountains of iron, a deposit of tungsten, vanadium, zinc, gold, silver and

nearly everything a man could wish for. There are already sixty-five manufactures in our city making over 100 products from this raw material. The desert is a vast treasure house for Los Angeles.

IRRIGATING THE DESERT.—To try to "reclaim" the desert—if it could be done—would mean not only injuring California, but the Eastern states as well. One cannot crop all creation.

The desert is the great producer of dry air. If it were possible to turn it into an agricultural tract it would increase the humidity and nullify practically the finest climate in America. The only ones who demand this sacrifice to the worship of the almighty $,$,$ are the same spawn of the infernal regions who would cut down the big trees, drain Lake Tahoe and make Yosemite a place of power plants.

Talk about the conquest of the desert! It only tolerates man as the ocean tolerates his mighty creations during her complacent moods. Sooner or later the desert will claim its own. Mankind only conquers spots on the earth for a little while. As soon as his fingers grow idle nature steps in and everything reverts to its natural condition again.

Some time in the future the sea may again lay limestones over the desert and a new history may start. It was not so very long ago, in geologic times, when New York State was a desert and great salt beds existed underlying Syracuse.

At present the desert is a vast treasure house, and a blessing. What is the future of the desert? "Quien sabe?"

MOUNT SHASTA

Mt. Shasta is the grand old mountain of California. It towers 2000 feet higher than Fuji-yama, the famous volcano of Japan, and it is only slightly lower than Mt. Blanc. It stands alone at the north end of the great valley. In simple grandeur and imposing individuality it rises high above its rugged neighbors, as a mighty monarch among giants, making a landmark that has guided many a weary pioneer; and it is surrounded by a vast panorama unapproachable in its splendor.

Its summit is 14,350 feet above the ocean and 8500 feet above its baseline, and its diameter is seventeen miles. Its crest is crowned with living, moving glaciers and white snow fields which are often penetrated by lavas of rosy hue, giving a beautiful effect as they glisten in the sun.

The upper cliffs slope with an average of thirty-five degrees, further down twenty, then ten, and at the base five degrees.

The base is well wooded with pine, silver fir and cedar and filled with deer and bear. The limit of vegetation is 8000 feet, leaving 7000 as a vast stretch of lava and snow.

Shasta is a typical volcano that has passed the prime of life and is now in the decline. It passed the stage of growth into one of decadence and is just beginning to show the ravages of time, yet one says: "Is it dead or simply sleeping?"

Vesuvius slept for centuries and then woke up and destroyed Pompeii. Shasta was active centuries ago,

but its energies are nearly exhausted and there is little danger of its waking up until future geologic revolutions.

Extinct Volcanoes

Mt. Shasta is the southern terminus of the Cascade Range which extends north to Mt. Rainier. This range was born at the close of the Cretaceous, as it rests on a foundation of Chico sediments, and has a number of extinct volcanoes along its course. From this range eastward is one of the largest lava fields in the world, covering 200,000 square miles, with a depth from 200 to 2000 feet. This lava sheet covers the northeast corner of California and extends from Oregon, across Idaho, into Wyoming.

This vast lava flood did not come largely from volcanic vents, but welled up from long and wide fissures in flood after flood, steadily and quietly and in immense volume.

Typical volcanoes like Shasta occur where lavas are forced up through short fissures or chimney-like passages, and build up cones around their vents. These lavas at Shasta occur as irregular masses overlapping each other like shingles.

There are two vents a mile and a half apart. The main vent at the summit covers several acres, with a well-preserved rim. It is now filled with volcanic debris and covered with snow and ice. Another vent, called Shastina, is 2000 feet lower than the main summit and has a well-defined crater.

On the west slope, near the base, are a number of cones, some of cinders and others of lava. At Lava Park there is a cone 200 feet high that has a well-

defined crater in its summit; but the upbuilding of the mountain mass has been by coulees, not by cones. By a "coulee" is meant a solidified stream or sheet of lava extending down from a volcano, often forming a ridge or spur.

Lava Park

Lava Park, 5000 to 6000 feet elevation, is the youngest coulee of the volcano. It is an exceedingly rough pile of lava rocks in angular blocks which covers an area two miles square and ends abruptly like a terrace. The magma was viscous and broke into sharp angular blocks as it was pushed over the surface. As this coulee lies on the southwest side of the mountain it was not scored by the ancient glaciers.

Each coulee presents a different aspect, the Trail Coulee being lava that was steam-torn and is hackly; Elk Flat has a bubbly, ropy surface; and at the Ash Coulee there are domes twelve feet high and fourteen feet in diameter that are great bubbles blown in the viscid lava. At the summit is a coulee of rare character, being composed of lipilli, the red, black rocks being the result of the last eruption from the summit crater. One coulee forms a lava cave, known as Pluto's Cave, which is over one mile long and lined with blisters and froth of lava. It is about two miles southeast of Sheep Rock and looks like a railroad tunnel.

The time when the coulees were formed can be figured out relatively. Geology shows that the Klamath Range dates back to the Jurassic; but it was sculptured into existing forms long before its neighbor, Shasta, appeared at the close of the Cretaceous. The canyon of the Sacramento River was also cut nearly to its

present depth long before the first eruption of Shasta. A cone on the west side sent a coulee that entered the canyon of the river and followed it for nearly fifty miles, and at Squaw Creek, four miles below Nabar, the lava formed a pond that is now a meadow. The river has cut a canyon 100 feet deep since this flow of lava; or since the Glacial Age.

The oldest lavas contain prominent crystals of hornblende of a light-gray color and are hornblende-andesite. It can be seen at Cone Mountain. The most abundant lava is hypersthene-andesite of a gray to black color and sometimes even reddish. The rhyolite is viscous and stiff. Basalt is found on the lower slopes of the mountain and on the plains.

Why Volcanoes?

The cause of volcanic action has been explained in several ways: as due to remnants of heat still existing from the "Age of Fire"; to the general contraction and compression of the earth, the heat flowing outward and concentration in certain zones; to the melting of rocks due to crushing, settling or depression, or by uplift.

If energies acquired under compression find sudden relief through the opening of a fissure or fault the dissolved gases would expand, forcing the lava column to a great height, and contact with water on the hot rising lava would furnish the explosive violence.

The dissolved gases are hydrogen, oxygen, carbon, nitrogen, sulphur, chlorine and fluorine, and many secondary vapors from their combinations, the principal one being steam.

An eruption is simply the expansion of these gases which roll out of the vent in cumulous or cauliflower

clouds of smoke that rise to great heights; in case of Krakatoa to seventeen miles in height, carrying the dust clear around the earth. The cooling of the vapors may turn to rain, causing floods of mud to sweep over the region.

Lavas are molten solutions of minerals dissolved in other minerals, like the slag of smelters; the whole mass being called a "magma" until it emerges at the surface, when it is called "lava." They are as hot as any furnace can produce, having a temperature from 2000 F. (1093 C.) to 3000 F. Like slags, they are classified as acid, basic and neutral. For example, the trachyte class are acid and fuse at 2700 F.; the andesite class fuse at 2500; while the basalt class are basic and fuse at 2250. As a rule the older lavas are the hottest and acid ones, and as the volcano grows old the lavas are basic. The last flow from Shasta was basalt, showing that the volcano has lost much of its energies and is getting sleepy.

Space does not permit descriptions of the bubbling hot springs, solfataras, places where the rocks are still hot enough to cook by; and a multitude of other interesting things.

The Whitney and four other glaciers, the vast snow fields where one finds patches of red snow and walks in crimson footprints; the tracing of the different zones of vegetation; the wild flowers; the surpassing grandeur of mountains and valley; all furnish material enough for a special edition of The Times.

LASSEN PEAK

While there are some 350 active volcanoes in the world, California has the only living, active one in all the States.

Lassen Peak, in Shasta County, is a nice, easy-going, respectable, spectacular volcano that is warranted not to terrify folks, only to interest them. It is simply "doing its bit" in furnishing news items to the press and calling attention of visitors to our geologic wonderland.

It is 10,437 feet above the ocean and its flanks are covered with lavas twisted and contorted into every conceivable shape and form; and the base reeks and bubbles with hot springs and pools of vari-colored boiling muds.

When the peak is trying to show off it sends up huge columns of smoke to attract the visitors and then flirts and threatens in a tantalizing manner; but its threats so far have been pure "bluff." Some of the bluffs are scenes of extreme beauty, with the moon hidden by the clouds lighted by the red glare of the volcano.

Lassen Peak stands in the midst of a northwest belt of volcanic cones that stretch from the Sierra Nevadas to the Cascade Range; or from the north fork of the Feather River to Pit River.

The lavas from over 120 craters join the bases of the cones so as to form a serrated ridge that is known as the Lassen Peak Volcanic Ridge—a ridge that is wholly unlike the Sierras in form, composition, structure and origin. The ridge is seventy-five miles long

by twenty miles wide and rests on the stratified rocks of the Cretaceous Age—Chico formation and contains peaks that rise 7000 feet above sea level.

Period of Activity

It began activity at the close of the Cretaceous and was very active at the close of the Eocene—Ione formation; but was most violent in the Sierran Epoch, when the Sierras were rejuvenated; and it has been spasmodically active ever since.

Before the Volcanic Ridge existed there was a strait filled with ocean water, between the Cascade and the Sierra ranges. As the Volcanic Ridge was slowly being built in this depression it changed the sea into lakes that were brackish at first and then fresh water. Here and there may be seen relics of former lake beds, known as the "Mohawk Lake Beds"; and sediments of the Miocene times, such as fresh-water mussels, and muds showing petrified magnolia, laurel, walnut and live oak leaves.

To the west of the Volcanic Ridge lies the "Piedmont Region" that is marked by the tuff deposits in the Miocene sediments, showing the activity at that date; and to the east lies the plateau that is the western boundary of the great basin.

A cross section of the Sierras at the south end of the ridge would extend from Honey Lake, in Lassen County, to the Sacramento River, a distance of eighty miles. This section shows three distinct crests with long, gentle slopes to the southwest and steep scarps on the eastern edge. This is characteristic of the basin ranges and is evidence of profound faulting and tilting of huge crystal blocks.

Cinder Cone

One of the most noticeable features of the district is Cinder Cone, a symmetrical truncated cone 700 feet high, covered with gray cinders and ashes with an unchanged crater at the summit. Pine trees growing in the crater show that the cone is over eighty years old at least and probably much more. The lava has cut a lake, just below the cone, in two and overflowed the banks into a grove of pine trees overwhelming them, the charred ends of the trees projecting through the lava. From this and other data there must have been a heavy eruption some 250 years ago.

The rocks of the Lassen volcano are mainly the rocks of the Jurassic, as serpentine, diorites and gabbros. The serpentine is of a different origin from that of the coast ranges, being the alteration of olivene, the original rock being peridotite. The first lavas were hornblende-andesite (lassenese) followed by pyroxene-andesite; then came rhyolites followed by dacite; and finally basalts, the last.

Curiously the basalts have been of great benefit as they formed dams converting the streams into lakes and swamps; and these in turn have become valuable agricultural land and the grazing land of the northeast part of the state. Basalt is a basic lava that slowly weathers into a very fertile soil, rich in plant food. One does not have to go to the vineyards of Italy or to tropical Hawaii to realize the fertility of basalt soils.

Plenty of examples may be seen in many of the counties in California.

Rich soils are not the only thing volcanoes give, adding to the wealth of economic minerals in the state.

Pumice is mined in several counties. It is a glassy lava foam that equals about 1 per cent of glass and 99 of air bubbles, making it so light that it floats on water. It is used in the arts for polishing, for filters, as a filler and for many other purposes. The different kinds of lavas find use as road metal, building rock, and one kind that can be sawed and shaped on a lathe as ornamental work. Several deposits of snow-white ash are mined as a polishing powder.

Craters Once Geysers

The northern Sierras are dotted with volcanoes and craters that were once gigantic geysers spouting molten rock instead of water. Some are recent and perfect in form, with crater lakes in their throats, others are in various stages of decay, overgrown with trees and flowers. In Mono, Inyo and San Bernardino counties volcanic cones are uplifted in lonely grandeur above the universal desolation of the desert; and there are cinder cones and lava flows of limited extent that are so lightly touched by erosion that they must be of a very recent date, for vegetation has hardly gained a foothold.

There is no space to describe the scenic delights of the Lassen National Park, as visitors will discover them; but everyone is interested to know something about the geologic facts that are not so evident, such as: volcanic outbursts that do damage to life and property are the exception, not the rule, and they are not the cause of the great earthquakes, although local tremors may accompany violent eruptions.

Active volcanoes occur along those borders of the continent that are being uplifted; being associated with

young mountains, where the land is rising and the ocean bottom sinking.

Their distribution has no relation to latitude, as they shun neither the cold of the Arctic nor the heat of the equator; but they do follow a linear arrangement with an appreciable curvature, the convexity of the curves being turned toward the adjacent ocean.

Volcanoes have had a large share in making California what it is; but one is glad to pay honor to their memory, rather than to enjoy their living beauty.

OUR COAST RISING

The Pacific Coast is slowly and steadily rising: A geologic fact that is easily proven. The realtors have long advertised that California is a young and rising country, and they should welcome the news that geology proves that it is true. We know that every land has "its ups and downs," and this state is now in one of its epochs of uplift; while the Atlantic Coast is in an epoch of depression.

The proofs of this may be seen and studied by anyone, for it exists in the form of wave-cut terraces on the hills along the entire coast.

If you go to Point Firmin, for example, and drive your car to the end of the boulevard, just west of the lighthouse, and look at the profile of the hills to the west, you will see that the hills are notched by a number of natural terraces, and a closer examination shows that they have been wave-cut, and are flat deposits of beach sands and gravel laid down upon the slanting older rocks, making a sharp "unconformity."

Each "terrace" or old beach marks the height of the hill above sea level at that time. Then came a time of rest, followed by another uplift and another wave-cut terrace. Of course, the highest terrace was cut when San Pedro Hill was only a small island of a few acres, a mere point sticking up out of the waters. With each succeeding uplift and terrace the hill grew higher and larger until now it stands 1482 feet above the ocean, and about ten miles long by four wide, and is the site of a fast-growing addition to our city.

Each terrace has its own records in the form of seashells and other fossils that tell what forms of life were in the ocean when that beach was cut by the waves. From these data one can write not only the history of San Pedro hill, but also that of all the terraces along the coast.

The upper terrace was cut after the Monterey shales were laid down, because the old beach lies flat, while the shales dip to the north. We all know that the Monterey sediments were muds on the bottom of the ancient Miocene Sea, and that they were uplifted when the coast ranges were born, and that the Miocene Sea extended to the foot of the Sierra Madre.

The next to the lower terrace was formed when the San Diego sediments of yellow and red sandstones were laid down in the Pliocene period, and that the last or lowest terrace was cut in the San Pedro epoch of the Pleistocene period.

Some of the lower terraces are as old as the oldest relics of mankind. The primitive Indians camped on them and hunted their sea food at the shore close at hand. This is shown by the mounds of seashells or refuse that the savages made, or "kitchen-middens" as they are known to the historians. The savages seemed especially fond of pectens, haliotis and chione, for we find these shells mixed with charcoal, arrowheads, flint chips, battle axes of stone and animal remains. The marl pits near Lomita show a fine section of this terrace. On top is the gravel of the ancient beach, with the relics of the Indians who once camped there. A few feet below is the white marl composed of seashells and sand, and containing the bones of whales, sea-lions and the teeth of mother sharks.

An excellent place to study the terraces is at San Clemente Island, as they are undisturbed by cultivation or other marks of mankind.

Anyone sailing about a mile from shore can obtain a fine view of these ancient beaches, at most points along the coast. One especially attractive place is along the coast of Santa Cruz County where four terraces, cut into the hills, can be seen at elevations of 100, 250, 500 and 800 feet elevation; corresponding very closely to the elevations at Los Angeles Harbor. Some of these terraces show holes bored in the hard rocks, when they were under water, by the rock-boring mollusk called "Pholas."

Students will be interested in comparing this gradual elevation of our coast with the general rising now going on in Chile, as shown by the recent disturbances there. They will also note that on the Atlantic the former canyon of the Hudson River is marked by a submerged channel extending out to sea far beyond Sandy Hook.

Verily, every land has its ups and downs.

CALIFORNIA'S ISLANDS

There is a system in the courses of the earth features that is not the result of chance; but the working out of definite laws, and these laws are illustrated in the channel islands of California.

The islands lie in line along a great curve, separated from each other by only narrow channels. They are submerged ranges or ridges of a chain of peaks along our coast, having a general northwest course. Some of the islands are mere needle-like peaks of offshore sierras that rise from deep water. Some are hardly large enough to label as Castle Rock, Wilson's Rock, Can Rock, Richardson's Rock, Bogg's Rock, Ship Rock, Church Isle, etc.

These islands are not built on independent lines, but each is a subordinate part of a chain, and the trend or course of the islands is as regular as are the mountain ranges on the land.

Our coastal islands from the Farallones of San Francisco to the Channel Islands off Santa Barbara and Los Angeles to the Coronado Islands south of San Diego are arranged in echelon along a great curve having a northwest trend. Each is elongated in the direction of the group, with outlying islets and rocks marking the extension of the line.

This is also shown by the soundings of the Coast Survey. In other words, they are not independent islands, but each is a subordinate part of a chain; the whole following the great torsion curves of the North American continent.

There are two great systems of trends, caused by torsion, that prevail all over the earth; one to the northwest and one to the northeast. This is easily recognized in the mountain ranges, but not so quickly noticed in continental islands lying from twenty to thirty miles off shore.

The North Atlantic trends to the northeast, or at right angles, nearly, to that of the Pacific.

The submerged extensions of the islands are a matter of great interest, for they are on a shelf or platform, upon which are mesas and peaks. The surveys of the bottom of the ocean made fifty years ago showed their existence then at the depth of 700 fathoms, or 4200 feet below water level. Surveys just completed show that the same peaks are now only thirty fathoms, or 180 feet, below the surface of the water. This is a remarkable discovery and is another proof that our coast is rising, as was stated in a recent article in The Times.

On the other hand, if our coast was depressed 100 feet, San Pedro Hill would become an island again, and if the coast was elevated slightly Cortez, Tanner and Osburn Banks would be islands again, for they were formerly islands that have been truncated by wave cutting. Coronado resort at San Diego was formerly an island, but is now united to the mainland by sand-reefs and marine marshes.

The rise of the submerged extensions of the islands is by no means uniform, but local; sometimes one portion rising, while the others are not affected. A rise in fifty years of about 4000 feet is very notable; for it means an average of eighty feet per year, or nearly seven feet per month. Of course, the rate has

not been as uniform as that; the main uplifts occurring as local earthquakes, such as the one felt recently along the northern portion of this state, occurring just off shore. It is, however, evident that the earth strain is persistent and that the earthquake but marks the relief of the strain along the fault lines. Vulcanism also affects the sea bottom as much as the land.

Observation shows that some shores are slowly rising and some are slowly sinking relative to the ocean level. We do not know that this movement is relative to the center of the earth or not; but a general shrinkage of the earth is probable.

Ancient islands existed long before the present ones as shown by the "cores"—protaxis—of the present ranges. These cores are igneous rocks that are very old; at least pre-Jurassic. The base rocks are crystallized and metamorphosed actinolite and hornblende schists; but underneath these are massive quartzites. This is a condition most prevalent from the Devonian down to the pre-Cambrian and is rare in later times. The silver-lead ores at Silver Canyon, on Catalina, are very similar in origin to those of Inyo County and to others in the desert that are pre-Cambrian. The geo-history since the Jurassic corresponds to that of the Coast Ranges. Miocene shale of the Monterey formation occurs at Catalina and San Clemente. There are Tertiary rhyolite, andesite and dacite flows, tuffs, ashes and breccias. The marine terraces of San Clemente are as noticeable as those of San Pedro. The islands were, also, connected with the mainland, as is shown by the elephant bones found on Santa Rosa.

Glancing rapidly over the geology of the islands one notes that they are all tilted crustal blocks, with the

precipitous side facing the coast. This tilting was not all done at one time, but varies from the Jurassic at Catalina to the Pleistocene at San Clemente; each island having its "up and down" independent of the others. Catalina was older and higher when Clemente was born and has evidently sunk some since.

Each island presents charms of its own in flora, fauna, topography and scenery; but these stories have been told many times, but certain special points about each island may assist the visitor in his studies and enjoyment.

Santa Catalina of the padres is the San Salvador of Cabrillo. It is twenty-two and a half miles long by eight wide and covers 50,000 acres. The topography shows one main ridge from northwest to southeast, with many spurs, culminating in Mt. Orizaba—Brush Mountain—2109 feet high.

There are no terraces, but sharp ridges that show the younger topography; while a few level mesas show the older.

It is a world-famous resort on account of the superb fishing and the marvelous beauty of the sea gardens. It is a veritable wonderland to the archeologist, a treasure house of prehistoric times, with its utensils of bone, wood, clay, steatite and lava; arrowheads, spearheads and war clubs of the Stone Age; beads, fish hooks, bone needles, bone whistles, earrings, ollas, mortars, pestles, metates; fish lines, hooks, sinkers and rings; awls of bone, shell money, cups, paint, paint pots and other relics of the dim past.

The Indians made their ollas—water jars—from the steatite they dug up in Pot Valley, at Empire Landing.

This island, like the rest, is a great crustal block that is tilted to the west. This tilting was not done at one time, but at intervals from the Jurassic to the present time. Like the Coast Ranges, the main rocks are of the Jurassic Age—Franciscan formation—cut by many dikes. In the Tertiary Age there were andesite and diorite lava flows, with tuffs and ashes; and there are Miocene shales of the Monterey formation that are gray in color and contain diatoms and interbedded tuffs and are known locally as the "Catalina beds."

In Miocene times, in the Coast Range epoch, this island was a noble sight off shore, as it was 2000 to 3000 feet higher than it is now; its crustal block having been depressed or lowered since that time.

San Clemente is the La Vittorio of Cabrillo and is noted for its sand dunes and marine terraces. These terraces consist of three major ones and four minor ones, corresponding closely to those of San Pedro Hill and other points on the mainland. The side facing the inland is precipitous as it is the scarp or raised edge of the tilted block; while on the other side the island presents a long, easy, terraced slope to the water's edge.

The highest point is Mt. Cortez, 1964 feet high. This island shows andesite, dacite, rhyolite and gabbro flows similar to Catalina; the Miocene and Pliocene sediments being cut by deep ravines.

San Miguel, or La Posesion Islas, is noted as the place where Cabrillo was buried in 1542. The Indians obtained ochre in the Point of Caves; and asphalt is found on the rocks, washed there by the

waves. It is reported that oil comes to the surface of the ocean at several points near shore. The geology is similar to that of Santa Rosa and Catalina.

Santa Rosa, or Las Islas de San Lucas, is seven miles long by ten wide, culminating in Mt. Negro, 1656 elevation. It shows the same geology from the Jurassic to the Pliocene as the others. While it is the largest of all the islands, it is also the most difficult upon which to land. It is noted for its sand dunes, which reach the height of 400 feet, and for the fact that the bones of an elephant were found there. This shows that this island was connected to the mainland during the Pleistocene and before the San Pedro epoch.

If the coast keeps on rising steadily, as hinted at by the recent soundings, then it will be dry land again to the islands; with a new coast line and harbors on deep water just beyond. What a picnic that will be to the realtors of the next century (?) to be able to extend our city limits for miles to "the southwest." Wonder if they will name any streets Tuna avenue, Bass, Swordfish or Yellow Fin streets?

Santa Cruz, San Nicolas, Santa Barbara and others have nothing different in their geologic history from the rest; but the searcher of records will find some curious facts such as the silver mining boom on Catalina in the '80's, or the gold excitement on Santa Rosa where the precious metal was found in the Jurassic rocks; or the boom in town lots at San Nicolas.

These islands are one of California's most valuable assets. Their real value is known only to a few, but the next decade will see thousands exploring their wonders and exploiting their values.

LAKE TAHOE

Lake Tahoe, the gem of the Sierras, is the largest, deepest and most beautiful lake in this state, crowded as it is with lakes and magnificent and entrancing scenery. It is also one of the most famous and charming bodies of fresh water in the world.

The very name has an aura of romance around it. John C. Fremont discovered it on August 14, 1844, and named it Lake Bonpland for the botanist who accompanied Humboldt to America.

The State Surveyor-General, in 1861, renamed it "Bigler" after the copperhead Governor. This name was changed to Tahoe largely through the efforts of Rev. Thomas Starr King. The word is Washoe Indian and means "big water."

The lake is 6225 feet above the ocean and occupies a trough between two parallel ridges in the crests of the Sierras.

This trough is known as Lake Valley and is some fifty miles long by twenty wide, and lies over 3000 feet below the surrounding crests. The lake itself is twenty-one miles long by twelve wide, covering about 193 square miles; large enough to float all the navies of the world.

The eastern boundary of the state runs through the lake, leaving two-thirds of the waters in California and the rest in Nevada. The outlet is by the Truckee River, which heads to the south and flows north through Lake Tahoe just as the Rhone flows through Lake Geneva.

The first thing that strikes the notice of the visitor is the purity and transparency of the air. It is not only rich in ozone, but its clearness is always commented on by the stranger, especially if he comes from the Far East. In England the air is full of fine particles of various kinds, dust, smoke and water vapor, and is so noticeably thick that one cannot see a mountain fifteen miles away with any clearness of detail, and there is a mistiness about the rock masses and a vagueness about the outlines that a field glass does not help.

Here, on the other hand, the air is so transparent and has a warm blue tint that is very different from the cold blue or chilly purple of Scotland. A lilac-blue veiling seems to hang over the mountains around Tahoe. Here mountains that are thirty miles away appear sharp-cut against the sky and at sunset the lights and shadows on the sides look as though only a mile or two distant.

One reason for this is the elevation, for at 2000 feet above the sea the blue in the sky is very noticeable; and at 3000 feet it deepens and darkens. At Tahoe it covers the mountains with a blue tint with a tinge of violet in it, while the night sky is royal purple, in which the stars sparkle like diamonds.

The temperature of the air is cooled by the lake, seldom going over 90° F. in the summers or to zero in the winters.

The summers are dry, with occasional thunderstorms; but very deep snows fall in the winter, covering the ground to a depth of from five to thirty feet.

The Lake Water

The transparency and color of the waters are remarkable as they are emerald green in the shallows along the shore, but brilliant blue in the deeper parts, while every object at the bottom may be clearly seen to a depth of from fifty to sixty feet, and a large white object to a depth of 120 feet.

The waters are very cool and no swimming is possible, as they have a temperature of about 60° F. at the surface to 39° at the bottom, fresh water attaining its greatest density at about 39° F.; but, in spite of its coolness, the lake never freezes. One curious fact should be recorded, that the pollen grains from the conifers, blown into the lake, do not decompose. This fact may explain the deposits of fossil pollen elsewhere.

It is the deepest lake in the United States, only Lago Maggiore and Lago de Como in Italy are deeper. There have been many traditions about the depth and many fables have been wiped out by the facts. Soundings have been made by the United States Coast Survey that give the maximum depth as 1645 feet just south of the Hot Springs. The depth rapidly increases from the south end to the north toward the terminal moraine left by the great glacial plow. The depths at other points are Rubicon, 850; Meigs Bay, 750, and at McConnel's, 700 feet.

There are rhythmical variations or "seiches" in the surface level of the waters, when the whole mass of water swings from shore to shore. This movement is attributed to the variations of the air pressure and to earth tides.

The Rocks

The whole region is full of charm to one at all interested in rocks and minerals and in the records of their various changes and origin; for the alteration of the rocks has been great in many places. Over 2000 feet of the summits have been eroded and the naked rocks lie weathered and cracked by the frosts of countless winters. The true granites probably formed a small range, or "protaxis," much older than the present Sierras. They can be seen on Mt. Rose, the highest peak on the Carson road, and on the east side of Job's Peaks.

Granodiorite of Jurassic Age forms the main core, or batholyth, of the Sierras and is especially prominent in Eldorado County. The great Sierra fault runs through the lake and is plainly shown at the Hot Springs, Scott's Springs and Rubicon Springs, where the waters all rise from the old crevice.

Shakespeare's Cliff, 700 feet high, is composed of spathic diorite of Jurassic Age; the grouping of lichens on the face of the cliff gives a resemblance to the great dramatist. Diorite also occurs at Pyramid Peak, at the head of Emerald Bay, and at Cascade Lake, Mt. Tallac—9785—is augite porphyry. Andesite of Pliocene Age is seen at Observatory Point and at Mt. Pluto—8700—and covers large areas to the north. Cave Rock, 150 feet high, is composed of porphyritic trachyte and contains a cave twenty feet long by ten high.

Basalt of Pleistocene Age is common from the lake to north of Truckee. Mt. Rose is a conical mass of

blue basalt broken through by the granite, while the summit is basalt laminated and iron stained. The old Jurassic sedimentary rocks have been largely removed by the glaciers; but the slates and shales of Sailor Canyon formation are still to be seen along Five Lakes and at Barker's Pass at 7000 elevation. Small patches of these rocks occur about a mile west of McKinneys and at the southwest corner of Fallen Leaf Lake and around Rockbound Valley.

There are volcanic vents west of the lake as at Mt. Lola, Castle Peak, Mt. Lincoln, Tinker Knob, Mt. Mildred and at Twin Peaks; but the greatest volume of the lavas poured out from deep fissures all along the crests of the Sierras.

Andesite lava of Pliocene Age, a rough, porous lava of dark brown color, can be seen at Mt. Pluto.

The Glaciers

The bowl in which Lake Tahoe lies was scooped out by a glacier. The great Lake Valley was formed in the rough in Cretaceous and Tertiary times; but later it was plowed, carved and polished by glaciers. The Lake Valley Glacier, starting near Silver Mountain, moved north. It was fifty miles long, fifteen wide and 2000 feet deep and received tributaries from the east and the west. This great mer-de-glace pushed its way down the valley between the confining mountains and plowed everything down to bedrock, the present lake occupying the deepest portion scooped out.

At one time the surface of the lake was 600 feet above its present level, and it is deepest at the upper or north end and shallow at the south end. A deep,

submerged channel of the preglacial river has been traced through the lake for eighteen miles.

As the main glacier melted the tributary ice streams also melted and left lateral morainal ridges along their sides and terminal moraines projecting into the lake. A good place to get a bird's-eye view of the paths of the extinct glaciers is from the top of Tallac Peak—9785—where one can see the morainal ridges running down from the summits and projecting as points into the lake. They mark the course of the ice rivers that once joined the main glacier that filled the big valley.

There are sixty-one glacial lakes around Lake Tahoe and each shows its origin plainly.

The terrific weight of the steadily moving glacier plowed the decomposed and softer rocks down to the hard igneous rocks and granites that form the bedrock. This bedrock is scored, striated and polished by the weight of 2000 feet or more of ice.

A good example of this is seen at Soda Springs, where the rock bottom of the canyon is polished and gently undulated like the surface of a billowy sea.

Emerald Bay is bounded on either side by moraines and the terminal bar of true morainal matter shows clearly beneath the transparent water. On either side of the creek from Cascade Lake to Lake Tahoe are perfectly defined moraines and from the lake up the floor of the canyon the rocks are polished.

The surface of Fallen Leaf Lake is eighty feet above Tahoe, but the bottom is several hundred feet below that level. This charming lake is bordered on each side by well-marked mounds of debris 300 feet high, four miles long and from one to three miles apart

marking the course of the Fallen Leaf Glacier that was 1000 feet thick.

The waters from the melting glaciers ran into the Truckee River and emptied into Lake Lahontan in Nevada, where the records of the advances and retreat of the glacier are recorded in the terraces of this extinct lake. This "fossil" lake was once 866 feet deep and covered 8422 square miles of Western Nevada and crossed the borders of our state.

One who has studied the history of Lake Tahoe will ever after look with wonder on the tiny snow flake, "the flowers of the air," that are so delicate and yet so powerful.

THE DEVIL'S POST PILE

Why travel across the ocean to see the Giant's Causeway or Fingal's Cave when the Devil's Post Pile can be reached by auto over the Roosevelt National Highway? About halfway between Mono Lake and Bishop auto signs mark the short road to the little hamlet of Mammoth, nestling at the foot of the mountain it is named for; then a horseback ride of three hours up the canyon to the Casa Diablo, the government headquarters in the new reserve at Red's Meadow.

The Devil's Post Pile is a place that may be visited in comfort and with pleasure for every moment; while the Giant's Causeway, on the north coast of Ireland, looks like a tumbled-down, decrepit pier, jutting into the bay, and can only be reached by a boat. Fingal's Cave, on the island of Jaffa, Scotland, is simply a tall hole, 200 feet long, made by the breakers of the ocean cutting a tunnel through the basalt column. It is a damp, disagreeable and often dangerous job visiting either one, as you have to take a skiff and toss among the breakers in order to see anything at all.

The Devil's Post Pile, on the other hand, is in Red's Meadow, recently set aside as a government park. It is in the heights of the Sierras at an elevation of 7500 feet, surrounded by snow-clad peaks, mirror-like glacial lakes, boiling hot springs and dashing trout streams of icy coldness. It is a fairyland of flowers and meadow set in a frame of pine, fir and tamarack.

The middle fork of the San Joaquin River rushes noisily through the meadow; and two miles down

stream the Rainbow Falls drop more than 100 feet, covering the black basalt with a filmy veil of water that gleams like silver in the sunshine.

The hot springs at Casa Diablo issue from a fault in the granite and food can be cooked in the hot ground around them. There are also a series of bathing pools where the temperature is down to 120° F.; and there is a soda spring bubbling with carbonated water.

The "Post Pile" is about half a mile northwest of the hot springs; and is a mile long by half a mile in width and from 300 to 400 feet in height. It is a splendid tower of the best-known type of columnar basalt, where the columns rise from 10 to 100 feet above a talus that is a tangle of broken "posts."

There is great diversity shown by the long, dark, glistening prisms that ring like iron when struck. Some are arranged in perpendicular rows as regular as huge organ pipes; in other places they lean or are gracefully curved; and some are twisted or wavy like hard candy. In another place they lie like railroad ties piled up against the hillside.

Some of the prisms are five-sided and others have six, seven or nine sides; and the columns range from eighteen inches to three feet in diameter. The prisms are convex at one end and concave at the other, so that they lock together, making the column look like gigantic honeycomb. The colors are mainly black, but some are dark green or gray, and a few are white and glisten like gems in the bright light. On the heights the tops of the columns are polished as smooth as glass by glacial action, showing that the Post Pile existed before the Glacial Age. Their geologic age probably

dates from the beginning of the Pleistocene period or the Sierra epoch, when the Sierras were rejuvenated or raised to greater heights. At that time there was a great outpouring of lavas, not from volcanoes, but from faults or fissures, where the lava flowed in sheets over the heights of the mountains.

Basalt lavas are especially fluid and when poured forth on the surface they spread out in deep sheets over the cold granites. In cooling they are apt to take on a columnar or basaltic structure, the columns standing at right angles to the cooling surface. Contracting from fusion produces fractures and gives the sides to the columns; the difference in the number of sides being due to irregularities in texture and rate of cooling.

The Devil's Post Pile is older than the Glacial Age; older than Nineveh or Pompeii; and snow, frost, tempest, earthquakes and all other disintegrating agencies have been busy trying to destroy it during untold centuries, forming a huge talus of broken columns at the base. Aged, gnarled and twisted cedars have grown up on this talus; while at the foot are groves of glossy quaking aspens. Shrubs of the Meadow-Sweet (Spirea lucida) thrive and bloom among the talus and soften the dark basalt with its flat-topped flower clusters. This shrub makes a refreshing summer drink that has received the local name of "Devil's Post Pile tea."

Botanists will find this region a rare place to collect flowers for the tall spikes of the scarlet bugler make solid masses of vermilion by the roadside; while brilliant masses of color of the yellow sulphur flower show

in the dry, rocky slopes; and low mats like pussy-paws appear among the rocks, the rose-colored petals in bunches like the cushions on kitty feet.

In the emerald meadow the large monkey flowers yield a delicate fragrance, and the charming, fragrant rein-orchis increases the charm of its alpine home. Tall stems of monk's hood—the blue weed of the miner—grows along the rivulets to torment the sheepmen with its deadly aconite. In the edge of the forest under the great firs, squaw's carpets of mahala mat delight the eye with their clusters of bright blue flowers in the spring and scarlet red fruit in the fall.

Scientists will find glacial lakes, moraines and polished rocks abundant; while faultings, lavas and the remnants of ancient topography will occupy their time fully.

To attempt to give an adequate idea of the beauties the artist will delight in—true alpine scenery—would require pages.

In spite of its Satanic name, this mountain park, with its basaltic marvels and with its many points of interest to scientists, its delights for the tourists, will soon become a favorite camping spot. It adds one more attraction to bring travelers to California—the world's geologic wonderland.

CORAL REEFS IN OUR DESERT

The natural place to look for a coral reef is around some South Sea island where cocoanut palms gracefully sway in the warm sea breezes; and the last place one would look is on top of a lonely mountain peak standing in a desolate, parched desert 150 miles from the sound of the sea.

"Facts are stranger than fiction," and a real and truly coral reef has been discovered in the heart of the Colorado Desert, in Imperial County; and, better still, the corals are not dull and dirty old fossils that show their ages, but they are as clean and snowy-white and young looking as any you can buy in the shell stores.

This coral reef cuts across Coyote Mountain—Carizzo Mountain—and also Fish Mountain—Black Mountain—that lies to the north. It is only about eight miles northwest of Coyote, well on the auto road from San Diego to Imperial; and the railroad passes within a mile of the reef at one point. The place is best reached by the old Butterfield stage road from Julian to the Imperial Valley. The old Carizzo Creek stage station is about five miles west of the reef and is marked by a large tule swamp and two good springs of water, affording a good camping place for the explorer. The corals are found in Barret, Garnet, Alverson canyons and other points on the reef, but the best place for the collector is near the head of Alverson Canyon on the south flank of Coyote Mountain, about a mile up the canyon from the old stage road.

The geology of these mountains is of special interest, affording a key to the formations buried to the east

beneath the hot sands of the desert. In Alverson Canyon about 150 feet of Miocene sandstones, sandy shales and conglomerates are exposed, which are known as the "Santa Margarita formation."

These sandstones have preserved the ancient corals in all their original beauty and, as the sands are not very hard, the splendid coral heads are readily cut out. To the east of the reef the slopes of Coyote and Black mountains are made up of a series of bedded tuffs, volcanic conglomerate—some of which is indesitic—and interbedded sandstones and shales. The shales are greenish, yellow and pink and are eroded and gullied into "badland" forms. The general dip of the strata is northeast, exposing three formations, as follows:

(1) Monterey formation of dark shales and sandstones.

(2) Santa Margarita formation of light-colored sandstones and greenish shales.

(3) Yuhua formation—named for the spring near the auto road—consisting of clays and sandy clays; merging into the sands of the valley.

It is not difficult to read the history of this reef as the mountains were islands in the Miocene sea; and are built up of volcanic material. The flanks of the mountain islands were submerged beneath the waters of a clear ocean which swarmed with fishes and was thick with seaweeds. Later on the clear salt water gave place to muddy waters in which the giant oyster—Ostrea titans—flourished and fattened.

At the close of the Miocene period, when the sea was withdrawn and the land elevated, the erosion of

the land began and the oysters and corals were buried under the later sediments.

A study of the corals and other fossils present leads to certain interesting deductions: (1) The coral reef is both Atlantic and Pacific in its affinities as some of the forms of life are related to those of the West Indies and Florida. (2) That means a water connection across Mexico in the Miocene period. (3) Later on the Atlantic forms of life grew less and less, indicating a land barrier across this water connection; while the Pacific forms of life increased. (4) That the temperature of the ocean was not less than 65 degrees F. during the coldest weather, and that the water was not deeper than 120 to 150 feet. (5) That the sea was frequently stormy, and the sunlight was bright and tropical.

The living forms of the corals, which are known as the "Flower Animals," are the same as those of the coral reef. When they are babies they swim freely, but later on they attach themselves to shells and stones and build up colonies of starlike cups, looking like tufts of glassy-white translucent moss. They are quaint little animals, having a cuplike body which has muscles that close the top, as a bag is closed with puckering string. They have long threadlike tentacles armed with barbs for catching their food, and they secrete a poison that paralyzes their prey. They can only exist where minute forms of foods are abundant; where the bottom of the sea is hard and free from silt; where the waters are warm the year through and not deep; and where the skies are bright and tropical.

The little bodies are divided by vertical plates and

secrete lime from the sea water, forming what we call coral.

There are a number of other coral reefs in this state, but none with such beautiful white specimens. In Inyo County in Waucoba Canyon there is a reef of sponge-like corals (Arcaocyathus) of Cambrian age; and a few miles south is a reef of honey-comb corals of Silurian age. Other reefs are known in San Bernardino and Plumas counties. All are high in the mountains from 2000 to 3000 feet above present sea level.

SALTON SEA

This strange and unique inland sea lies over 200 feet below sea level in the extreme north end of the Coahuilla Basin. The region is a scenic wonderland that will attract thousands of tourists as soon as the boulevard is completed; especially as the sea is full of marketable fish, and alive with ducks and geese.

Salton Sea lies in a desert plain that has been covered with the rich silt of the Colorado River delta.

The southern portion of this plain is locally known as the Imperial Valley, which has been converted into a veritable garden which produces over seventy-five million dollars worth of agricultural products, cotton, casabas, and dates being the leaders.

In July, 1891, Salton Sea was twenty-five miles wide by forty long, and was 226 feet *below* sea level. A large salt factory stood at the north end, and several miles of track stretched out over the white salt beds. Later the Colorado River broke in burying the salt works in the depths of the sea; and compelling the Southern Pacific railroad to move their tracks nearer the foot of the mountain.

The Coahuilla Basin is enclosed by mountains except to the south where the basin is separated from the Gulf of California only by the alluvial dam or ridge of the Colorado's delta. On the north and northeast are the Chocolate, Cottonwood, and San Bernardino mountains, forming a continuous range. They are built up by pre-Cambrian granites associated with gneiss and schist, with intrusive granites of the Juras-

sic Age. The west boundary of the basin is the lofty San Jacinto Range.

The whole basin is a structural trough dating back to pre-Cambrian times; the axis of the trough being the locus of a major fault line that is a continuation of the great San Andreas-Cajon fault that runs in a northwest direction.

The basin presents a picture of rugged bordering mountains half buried in long smooth-shaped aprons and alluvial fans which merge into a central flat covered by the sea.

The east side of the basin is bounded by the Colorado River, which is 150 feet above the ocean level at Yuma; but before it reaches the Gulf, its waters spread over the vast delta in a puzzling network of branches. One of these branches turned to the north, on the sloping delta, and crossed the Mexican boundary, and entered the Salton Sea in 1905-1906. This flood of water was only conquered after an expensive and spectacular struggle.

This delta is composed of alternating beds of fine sand and silt which are easily cut by the flood waters, as are the sand dunes.

The Salton Sea of today is but a vanishing remnant of a larger and more ancient sea. There still exists an ancient shore line which surrounds the basin, and lies forty feet above ocean level. It is clearly seen as wave-cut terraces on the alluvial slopes, and cut into the rocky spurs of the mountains; and in places it is marked by crusts of travertine. Some of the minor strands, or beaches, still show marking the gradual evaporation of the waters; the whole forming clear

records of an ancient lake that extended just beyond Indio.

This ancient sea has been named for Professor William P. Blake, the geologist of the government expedition sent out to explore railroad routes to California. He was the first geologist to see and map these old beach lines when he traversed this dreary waste on November 23-25, 1853.

Blake Sea was a freshwater lake, as freshwater shells are scattered all over the region occupied by its waters; also the deposits of travertine are freshwater; and the salt in Salton Sea is the result of the leaching of the rocks of the surrounding mountains, and is but a small fraction of what it would have been if Blake Sea had been marine. As to age it is probably cotemporaneous with Lake Lahontan of glacial times.

The Indians have traditions of this former lake, that it was once filled with fish and slowly dried up; and of the sudden breaking through of the Colorado River, which drowned many of their tribe.

Mud Volcanoes

Near the southeast edge of Salton Sea are the mud volcanoes, which are quiet at present, but which are reported to have thrown steaming mud fifteen feet into the air in different eruptions. They are situated near the great fault line, as are the numerous fumeroles, hot springs and boiling pools, inactive mud cones with extensive deposits of sulphur, alum and salines.

A second group of hot springs and mud geysers occur just north of former buttes—now islands in the sea—that are composed of volcanic rock, pumice, glassy obsidian, and volcanic tuff of Tertiary Age.

At Mullet Island are "paint springs" that are steaming masses of vari-colored mineral pigments. These have been used to paint his cabin, by Capt. Charles Davis, who abandons chasing the aristocratic codfish off Massachusetts, for the oily but humble mullet found in this lake in the desert.

There is a third group of hot springs near Lano, but they are small and nearly extinct.

Geological History

A summary of the geologic history of the Coahuilla Basin is as follows:

1. The trough of the basin dates from pre-Cambrian times.
2. This trough was deepened and modified by faulting at the time of the birth of the San Jacinto and San Bernardino ranges, which took place at the end of the Jurassic Period, and the intrusion of the granites.
3. The Mud Hill series of sediments were deposited in the north part of the basin, at the time when the Miocene Sea covered the southern portion.
4. The retreat of the Miocene Sea was accompanied by the extension of the Mud Hill series of land sediments to the south.
5. In the Pliocene the Mud Hill series were bent, broken and distorted.
6. From the Sierran epoch to the present time the Mud Hill series were eroded and carved into their present fantastic forms.

This series takes its name from the Mud Hills at Mecca, and are from 3,000 to 5,000 feet in thickness. They consist of a basal conglomerate resting on the

pre-Cambrian granites and Jurassic granites. They are composed of arkose sandstones, reddish clays, intermixed sandstones and clays, with mirabilite, and large deposits of gypsum. The whole series extends from the late Miocene, through the Pliocene, and into the early Pleistocene. It is a series of land sediments, and not marine; and it is typically "bajada" (ladder like), or a series of steps that merge into the central sink of the Salton Sea.

The Mud Hill series contain several kinds of raw chemical materials; but the only ones mined at present are the abundant gypsum deposits. The entire basin and its bordering mountains will become famous for its mineral resources as well as for its cotton fields—sodas, pumice, alum, granite and other building material, road metal—while the bordering mountains are rich with vast deposits of iron, gold, silver and gem mines that have been worked for years.

This "dreary waste" of the pioneers is rapidly becoming one of the "white spots" commercially of California.

LAKE LAHONTAN

A friend said to me one day, "I wish we had a weather report for the Glacial Ages; it would be of so much value to science!"

He was very much astonished when I told him that we had that very thing in the records of Lake Lahontan; a record covering thousands of years, with hosts of details.

Lake Lahontan is a "fossil lake" that has nearly vanished, but it formerly covered 8,422 square miles, was over 866 feet deep, and had no outlet. It was fed by the waters from the glaciers on our lofty Sierras and lay largely in Nevada, but lapped over our state line in some places.

This extinct lake was almost the size of Lake Erie—which covers 9,000 square miles—but was nearly three times as deep.

The former existence of Lake Lahontan—named for a famous explorer—is clearly proved by perfectly preserved beaches, wave-cut terraces, water-built embankments and marginal lines of lake-cliffs by which the shores have been surveyed and mapped. The sediments deposited by the lake lie in terraces on the flanks of the steep mountains which border it, and on the many islands that dotted it.

The beach lines show that the level of the lake was ever rising and falling, each shore line marking a pause and its relative duration. As it had no outlet its rise and fall depended upon the alternating water supply

from the glaciers and the rain belt that bordered it; hence the period of filling up and going dry, form a geologic barometer.

Its rise and fall was due to the movement of the rain belt along the advancing and retreating glaciers, so that it furnishes a complete record of the maximum and minimum times of glaciation.

The waters of this lake covered the areas now occupied by the Madaline Plains; Horse Lake, Eagle Lake and Honey Lake in Plumas County; Mono Lake and minor lakes southwest of it, and existed at the same time as the Blake Sea—Salton Sea—the lake that filled Death Valley and many other valleys of the desert.

The upper terraces consist of marly clays fifty to seventy-five feet thick, the middle terrace of medial gravels from fifty to 200 feet thick, and the lower of 100 feet of clay.

The different terraces should be studied according to their order of sequence in time, and not from their relative elevation above the ocean. The order of sequence is as follows:

1. *The Embankment.* At the end of the Pliocene period the Great Basin was as arid as it is today. The beginning of the Pleistocene, or pre-glacial epoch, was a time of great erosion carrying an immense amount of debris from the rising Sierras into the valley below. Such sediments formed a great embankment across Humboldt Valley in Nevada. This embankment can be seen today at the south end of Humboldt Lake. It looks like a great railroad embankment standing from fifty to sixty feet high, and sweeping clear across the

valley. This formed a dam that held the waters that formed the beginning of Lake Lanhontan, a fresh water lake.

2. *The Lithoid Terrace.* This marks the first Lanhontan rise. It is named for the Lithoid Tuffa deposited. It is thirty feet below the highest water mark, indicating that the second time of glaciation was the greater. It has a width of from 200 to 300 feet, and its sediments are gray and compact and contain fresh-water gasteropods. The lake was 470 feet deep at that time. This epoch marks the time of the first glacial period, for the waters were largely furnished by the glacial streams, supplemented by a light local rainfall among the desert peaks of the surrounding region.

3. *Desiccation.* Then followed an epoch of desiccation when the waters from the glaciers nearly ceased, and the annual evaporation was greater than the snowfall and rain. This time is known as the Inter-Glacial Epoch—the time when the waters fell below the present level of Pyramid Lake.

This inter-glacial epoch must have continued for centuries and is of exceeding interest to all mankind. The history of primitive man can be definitely traced back as far as this epoch, but beyond that all is mere guesswork and theory. Rude sculpture, cave drawings, artifacts and other material, prove that mankind was familiar with the animals that live in the inter-glacial times: the mastodon, hairy mammoth, camels, llamas, giant ground-sloth, saber-toothed tiger, cave bear and others. Then the second glacial period started, and as the climate gradually grew more severe these animals became extinct; not directly through the

cold, but from the loss of the food supply, bacterial diseases, or other causes.

4. *The Thinolite Terrace.* As the waters rose again they evidently stood for a long time and were subjected to heavy evaporation and concentration, for this terrace consists of thick deposits of gray, crystalline, thinolite tuffa. The terrace is broad and sharply cut and stands some 400 feet below the Lithoid Terrace, or only about 100 feet above the level of the present Pyramid Lake. This phase or episode in the history of the lake towards the end of the Interglacial epoch is of more interest to the chemist than to the geologist, on account of raw chemicals in the deposits. It was a time of moderate aridity as the glaciers were not able to furnish enough water to balance the evaporation.

5. *The Dendritic Terrace.* Three hundred feet above Pyramid Lake. At this time the lake became half filled, showing an increase in glaciation when this terrace was cut, and the deposits of dendritic tuffa laid down on the flanks of the mountains.

6. *Second Glacial Epoch.* This was followed by a time when the lake rose to its highest point, thirty feet above the Lithoid Terrace, and had a depth of 866 feet. Lake Michigan has a depth of 600 feet, and Lake Erie about 300 feet.

7. *Desiccation.* Then came the final evaporation of the lake to dryness, and its disappearance. There is nothing left now but the shore deposits, old beaches, and some sinks or pools in the deeper depressions in the floor of the desert as the Carson and Humboldt sinks. This marks the beginning of the same conditions as exist today.

A host of details of geologic history are brought out by a study of the shores of this old lake, for example: The Truckee River cut its first canyon in the hard rocks of the rejuvenated Sierras, in the Sierran epoch, and fed young Lake Lahontan with fresh water, forming a delta where it entered the lake, while in glacial times the Truckee has cut a new canyon through its own former delta.

Lahontan Climates

The climate of Lahontan times—Glacial times—was not necessarily humid in general. The lofty Sierras that had just been rejuvenated had some peaks towering 20,000 feet above the ocean level, and the whole range was over 4,000 feet higher than it is now. That would rob the moisture-laden clouds from the ocean causing an enormous snowfall on the crests, causing glaciers to form, while the rainfall over the rest of the country was light. The general area of the Great Basin may have been nearly as arid as it is today when the streams, or arteries, of the parched and heated country make but one feverish pulsation in a year. Deserts occur wherever the evaporation exceeds the water supply; while lakes form wherever the water supply exceeds the evaporation; and the glaciers supplied this lake, in the arid desert, with water which could not escape, as the basin had no outlet. As glaciation increased so did the rain belt along its edge. When the snowfall decreased and active glaciation was checked, the lake promptly dwindled.

The records of the Lahontan climates have been subdivided by the government geologist, as follows:

1. *Pre-Lahontan.* Arid, rain small, evaporation rapid, temperature high; lake small, no glaciers.

2. *First Rise.* Rain moderate, evaporation slow, temperature low; lake large; glaciers in the mountains.

3. *Inter-glacial.* Rain small, evaporation rapid, temperature high; glaciers small, lake dry.

4. *Second Rise.* Rain moderate, evaporation small, temperature low; broad lakes, large glaciers.

5. *Post-Lahontan.* Very arid, rain small, temperature higher than now; lake desiccated and glaciers melted.

6. *Recent.* Rain small, evaporation rapid, temperature 50 degrees; land arid, rivers small and intermittent; lakes and glaciers small and few in number.

* * *

What of the future? Will a glacial age return? The fact is we are now living in the fag end of the glacial times in California as we have a few remnants of glaciers still living among the highest peaks. The great glaciers have vanished from that portion of Canada immediately north of the Great Lakes, but they still exist in Greenland, in Northern Canada, and in Alaska, and in other places.

Nature advances in cycles that are not as circles, but as spirals, ever upward as well as onward. "What has been, will be," says the proverb. Another time of ice may come and the species Homo may be wiped out and become as extinct as the dodo.

"What will be the next step in progress?" Let the evolutionists answer the question! One says that "the man of the future will have wings." Let us hope so.

CALIFORNIA CAVES

The caves of California have been ignored by the publicity writers because they are off from the main traveled roads, and lack hotels and other accommodations. Some of them will attract visitors on account of their beauty and size; others because they are closely connected with the days of romance and early mining; and others for their interest to scientists as they contain the fossilized bones of strange animals of bygone days.

Crystal Cave

This beautiful cave is in the Sequoia National Park, one and a quarter miles by road, and three by trail from the Colony Mills. It is a cavern carved out by streams and leached out by waters, in the limestone of Carboniferous Age. Only about one mile of passages have been explored, but the unexplored openings promise many more, and it may rival Mammoth Cave, in Kentucky, in size and interest to visitors.

This cave is not only remarkable for the size of its chambers, but for their variety and the richness of their fantastic decorations and colorings. It is studded with crystal gems, while gnomes and fairies have worked marvels in stalactite and stalagmite from the elfin to the majestic.

The government has taken steps to light the first mile with electricity. Two waterfalls and a soda spring near by add to the interest and charm of the place, which will soon attract and hold its hosts of visitors.

Mercer's Cave

Mercer's Cave, or Murphy's Cave, is in Calaveras County and was well-known to the miners. At one time the little hamlet was known as Cave City, but today only a small house set in a thicket of fig trees marks the spot where, "in the days of old, in the days of gold, in the days of '49," the miners gathered to dance, gamble and make merry in their rough but hearty way.

The cave is not extensive, being developed along a fault, or fissure, in the Calaveras limestone of Carboniferous Age.

Narrow alleys lead from chamber to chamber in which are found fairy alcoves and tables of stone. Natural marble stairways lead to upper chambers for three or four stories in height, and the ceiling and floor and walls are all decorated with crystalline stalactites and stalagmites in various forms of beauty. There is not only a dance hall where one may try the latest fox-trot, but there is a "Chapel" with sermons in every stone. Tradition says that several couples have taken their vows, for better or for worse, in this chapel.

The scientist will be interested in learning that in the earth fan at the entrance was found the remains of the Megalonyx, or giant ground-sloth. It was a degenerate mammal that had the teeth and head of the sloth, and the tail of an ant-eater. Its thigh bones were two or three times the thickness of those of the elephant. A creature quite capable of toppling over small trees in order to feed on the leaves.

As it dates back to inter-glacial times it may have made a nice pet to the cave man prospecting on the Mother Lode.

Potter, Samwell and Hawver's Caves

The Potter and Samwell's caves are both in Shasta County on the McCloud River, while Hawver's Cave is in Eldorado County five miles east of Auburn, on the north fork of the American River. The origin of the three caves is the same as all have been leached out of the Pennsylvania limestone of Carboniferous Age.

The Potter Cave is two miles above the mouth of the river, near the U. S. Fishery Station, and Samwell's Cave is eighteen miles further up the same stream.

There is not much interest in the stalactite formations, but the main interest in all of these caves is the fact that the floors of the three caves have proven storehouses of the bones of mammals that had been swept in by ancient river floods.

Out of a total of thirty-seven genera and fifty species, thirty genera and twenty-two species are still living. Among the extinct species are found the following animals of the inter-glacial times: the ground-sloth, the huge mastodon, cave bear, lion, bison, camel and saber-toothed tiger.

One may shut his eyes and picture the scene of this tropical menagerie living during the mild inter-glacial age, wandering in forests of maple, elm, ash, hickory and basswood, as identified by their fossil leaves. What destroyed these animals? Was it the coming of the second glacial times and the destruction

of their food supply, or some convulsion of nature, or something started by lowly bacteria? "Who knows?" as our Spanish friends say.

Pluto's Cave

This is a weird, gloomy cave, unlike any other in the world. It is two miles south of Sheep Rock on Mt. Shasta, and looks like a huge railroad tunnel that is over a mile long. It is simply a huge hole left in a torrent of lava when Mt. Shasta was a living volcano, more terrifying than Etna, and is lined with the blisters and froth of the boiling, steaming lava.

It was formed when Mt. Shasta was veiled by thick clouds of smoke and vapor—a land of fearful night—and through the darkness glows crimson lava, a flood of fire flowing from the broken lips of ragged gashes in the crater. As the molten mass grows darker, and cools and hardens on the surface, or by contact with the rocks, a stream of bubbling, frothing, liquid lava flows out, leaving the tunnel to mark its course.

OUR BIG TREES

The "Big Tree," or Sequoia gigantea, is not only of interest because it is the oldest living thing on the face of the globe; or that it is the largest forest tree in America; or that it is found only in this State; but it is of especial interest to Californians because the annual rings of growth give an accurate and clear record of the climate for 4,000 years, and prove that it has been of the same type as that of the Mediterranean province. More than that, the annual rings of the fossilized trees extend our knowledge of the climatic pulsations, to and fro, clear back to the Mesozoic, or middle, age of the earth history. The big trees, therefore, belong among the wonders of this geologic wonderland.

The Sequoia gigantea belongs to the Coniferales, or needle-bearing evergreen trees. That is the right name for it, being given, in 1846, by a French botanist. The name S. washingtonianum did not appear until 1898. The big trees were classified, by some, as Toxidium washingtoniana as early as 1854; they have been called Sequoia wellingtoniana by English writers; but S. gigantea holds firm both by priority and as expressive of character.

(Encyclopædia compilers please note.)

The name Sequoia honors the Indian of the Cherokee tribe who invented an alphabet, in 1821, for his people. His tribe learned to read and write it, and it proved very useful commercially, in spite of its many absurdities. Sequo-Yah—or George Guess, as the

white men called him—was born in an Indian village on the present site of Tuskegee, close to old Fort London, Tennessee. He did not know even the sound of the letters and characters he was using, picked from an old spelling book, and he used capitals, lower case, italics, and letters upside down as symbols, until he had eighty-five, or one to each sound of the Cherokee language. It is fitting that California should honor this Edison of the redmen.

* * *

The leaves of the Sequoia are awl-shaped, short, rigid, and pointed, being alternate and spirally inserted. The young trees are more rigid and formal than are the redwoods—Sequoia sempervirens—the stem rising straight and tapering, the drooping branches at first touching the ground. The lower branches are soon drooped and the upper ones become thinned out.

The tallest tree is 325 feet in height, and thirty-five in diameter, with densely spreading branches, and a rounded or dome-like shaped head; and the trunk bare of branches for 150 feet. It stands lonely, silent, serene, and majestic. It represents strength, and beauty combined with a stern and solemn mien.

Its roots are a net-work extending for over 200 feet, but it has no tap-root. The bark is of a bright cinnamon color, and channeled with vertical furrows. The bark of one of the trees was stripped off for 150 feet and exhibited all over the east, and now rests in Crystal Palace of London—but it killed the tree. What vandalism!

At the end of the winter, while the snow is still deep on the ground, the pale green flowers are in myriads at the ends of the sprays. The winged seeds are very

small and light and are easily carried by the softest breeze. The big tree can only be replaced, or grown, from the seed; while the redwoods sprout from the stump.

The big trees grow in detached groups, at elevations of from 6,000 to 7,000 feet, all along the western foothills of the Sierras; from Placer to Tulare counties. There are fourteen groves, with over 12,000 trees that are over ten feet in diameter, all growing in a region of surpassing grandeur; and mingled with other coniferous trees.

A temple whose transepts are measured by miles,
Whose chancel has morning for priest,
Whose floor-work the foot of no spoiler defiles,
Whose musical silence no music beguiles.
No festival limits its feast.

—*Swinburne.*

In these groves the pines, cedars, and firs are all of greatest height and girth; yet the big trees dwarf them and look like a mammoth in a deer park. Surrounded by a garden of wild flowers the big tree grows to a picturesque old age, in a region where the climate is mild, and where they can enjoy moisture and sunshine the whole year around. It is only in the California climate that they have been able to make their last stand in their century prolonged struggle for existence.

They are the oldest living thing on earth. The tortoise lives 350 years, the elephant 130, the eagle, swan, and parrot 100, mankind 70 years, with a maximum of 130, the horse 40, cray-fish 20, and so on; but some of the living trees are 4,000 years old. To think of it makes one pause on the threshold of his future, and have a profound respect for the past; for some of these

trees were aged when Moses wrote, "In the beginning," and when the Nile valley was the center of population and civilization. They were middle-aged when the Star of Bethlehem hung over the manger; and it was but as yesterday when Napoleon "parked his troops in front of the Sphinx." Therefore they have felt all of the climatic changes that have occurred for century after century.

* * *

The big trees have a record of all these climatic changes. This record may be read and studied in the annual rings of growth which point out clearly the seasonal changes. The tree grows rapidly each spring and summer, and rests in the fall and winter for, say a hundred years; then the rings show uniform spacing and regular growth. Then may come an epoch of irregular or interrupted progress. The changes are shown by the deposition of darker and denser material in the cell wall; or the reverse. The growth is affected by snow, rain, and temperature. When there is an abundance of water for a long period then there is a beautiful rhythm of annual rings shown which correspond to the sun-spot cycle of 11.4 years. Other cycles of six, twenty-two, thirty-five, and 100 years are shown.

These records have been compared with those of the Mediterranean province proving that they are of the same type for the pulsations are those of the big trees. It must be of interest to every Californian that we have records of the past to be used in judging the future. That the pulsations back and forth, while they are never still, yet maintain the same type as that of the famous Riviera; or specifically the coast of

France and Italy from Nice to Spezzia, should give a bright outlook for the future.

* * *

The records of the annual ring does not stop with the living trees for they are preserved in the fossil sequoias that once formed extensive forests in many parts of the globe. The sequoia has perished in Alaska, Iceland, and Greenland, as the glaciers advanced.

Beautiful agatized specimens have been found in the Yellowstone Park, and along the foothills of the Rockies. They have been found at Great Falls, Montana, and along the Potomac River in the south.

In the petrified forest at Holbrook, Arizona, the specimens are now quartz, beautifully colored, while the rings show as clearly as those of the living tree. At the petrified forest, in Sonoma county, the fossil sequoias are gray colored, excepting where the tree has been burned, then they are black. This forest is covered with volcanic ash, and they record a former volcanic eruption, accompanied by an earthquake which tumbled all the trees to the west. In examining these specimens it is interesting to note the worm-holes bored into the bark—holes made by insects centuries ago.

The glaciers south of the Yosemite did not extend down the mountain side as far as the Wawona grove; but must have buried many acres of big trees east of that point. If so, in the old moraines is the place to look for relics.

The sequoia was spread world wide at one time; and over forty species are now known. They are the surviving links between the firs and cypress. Their ancestors are the *Leptostrobus* and *Swedenborgia* of the Jurassic period, and the *Voltzia* of the Triassic; all

being of great size. The sequoia began developing in the Cretaceous and reached its greatest point during the Tertiary age. It is found in the Cretaceous of Atane, Greenland; and in the Olegocene coal beds of Europe.

During the Tertiary these trees ranged from Greenland on the north, to New Zealand on the south, as great forests.

The records are accumulating in the form of polished sections of fossil sequoia, that will perfect the records of the climatic changes in the ages past, even from the time the world was middle-aged. When the Government publishes such a folio it will have a big sale among our wide-awake realtors for: "The best prophet of the future is the past."

THE ARROWHEAD HOT SPRINGS

I stated, on other pages, that I visited the Arrowhead Hot Springs in 1880; and during the last fifteen years I have spent many happy days there. This is written from a sense of duty to other sufferers, and not as a solicited or paid advertisement, but in gratitude for what these hot springs did for me.

In April, 1915, I had a "dizzy spell" in my class room, and in the afternoon walked around down town until a swelling leg stopped me. That evening a doctor was called in, for a partial paralysis of the right side of the body had set in, and the right leg was swollen almost to the bursting point. A fibrinous clot had choked the circulation below the knee (a thrombus), and inflammation of the veins had started (phlebitis).

The "Doc's" notes probably included the following:

"Bailey, G. E.—Prof. in U. S. C.; age 63, height over six feet, weight 287 lbs.; athletic, temperate; disposition, obstinate and cross, etc."

After six weeks in bed while kind nurses and friendly doctors urged me to be scientifically carved at various places from my knees up to the neck, especially the latter, I found myself being carried into the hotel at Arrowhead.

The next day, after a sleepless night, a partial mud-bath was used. Did I enjoy it? How can I tell when I fell asleep while the attendants were applying it? The burning, torturing pains I had suffered from, fled like magic when the soft, soothing, black mud was applied.

In forty-eight hours I propelled a wheel-chair into the dining-room and enjoyed a meal with the rest of the guests, and September found me again in the class room, using crutches. I was still weak from my knees down, but that did not count so long as I was in good shape from my neck up. I never have to do any "kicking" in my classes anyway.

Today, at age of seventy-two, my weight is 240, and even the cane has not seen use for several years; while boxing, swinging Indian clubs, and other athletics have been resumed.

"Diet," did you ask? Huh! I have always been a light eater, seldom eating more than two meals per day. Arrowhead waters, milk and buttermilk, for liquids; whole wheat bread, no starches or red meat, and plenty of fruit and vegetables.

The secret of the "cure" is found in the mud-baths, vapors of the steam caves, and the *living waters* that bubble out in the shadow of the great Arrowhead. They are living waters full of magic, full of forces and latent powers that we misname "electricity, chemism, magnetism, radio-activity," and so forth.

When you drink the waters, these latent forces are released and set free, and you feel new life thrill along each nerve and pulsate in every vein. When you bathe you bombard the body with a host of mysterious vital forces that soothe and stimulate at the same time.

There are marvelous mysteries concealed in the drops of water from the hot springs and I am going to ask the Arrowhead Springs Water Co. to print a special paper to tell you something about these "mysteries." Write to them for it at 1566 E. Washington St., Los Angeles, Calif.